A COMPARATIVE STUDY OF CONTRAST SENSITIVITY AND DEPTH PERCEPTION BETWEEN MYOPES AND HYPEROPES

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DEDICATION

I humbly dedicate this project to God who has been with me throughout my journey in the University of Benin and has consistently shown me his love and mercy.

I also dedicate this project to my parents Mr and Mrs Eze Hyginus Okere for their unwaveringly support,love and care.

CERTIFICATION

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ABSTRACT

Background:Contrast sensitivity and depth perception are critical components of functional vision that extend beyond conventional visual acuity assessment. Myopia and hyperopia, as common refractive errors, are known to alter the optical quality of the retinal image, potentially affecting contrast detection and stereopsis. However, the degree and pattern of these alterations remain inconsistently reported in literature. Aim:This study aimed to compare contrast sensitivity and depth perception between myopic and hyperopic individuals with best-corrected visual acuity of 6/6, to determine the extent to which these refractive conditions influence visual performance. Methods: A cross-sectional analytical study was conducted among participants with diagnosed myopia and hyperopia attending the Optometry Clinic. Contrast sensitivity was assessed using the Pelli-Robson Contrast Sensitivity Chart, while depth perception was measured with the Lang stereotest under standardized illumination and testing distance. Refractive status was confirmed through objective and subjective refraction. Data were analyzed using appropriate statistical tests to compare mean contrast sensitivity and stereoacuity values between refractive groups, with significance set at $p < 0.05$. Results: The findings demonstrated a statistically significant reduction in mean contrast sensitivity among myopes compared to hyperopes ($p < 0.05$), indicating that myopia has a greater detrimental effect on contrast detection, particularly at lower spatial frequencies. In contrast, hyperopes exhibited relatively preserved contrast sensitivity but showed mild variability in binocular fusion responses. Regarding depth perception, myopic participants displayed poorer stereoacuity thresholds compared to hyperopic participants, suggesting that optical blur and aniseikonia secondary to myopic elongation may impair fine binocular disparity processing. No significant association was found between gender and either parameter, while age showed a mild negative correlation with both contrast sensitivity and stereopsis. Conclusion: The study concludes that myopia exerts a more pronounced impact on both contrast sensitivity and depth perception compared to hyperopia, even in the presence of full optical correction and normal visual acuity. These findings highlight the importance of including contrast sensitivity and stereopsis evaluation in routine refractive assessments to provide a more comprehensive understanding of visual function.

KEYWORDS: : Myopia, Hyperopia, Contrast Sensitivity, Depth Perception, Stereopsis, Functional Vision,

CHAPTER ONE

1.0 INTRODUCTION

Vision is a critical sensory function that significantly influences daily qactivities and overall quality of life. It relies not only on sharp central vision but also on the ability to detect contrast and accurately perceive depth. Contrast sensitivity and depth perception are two of the many aspects of visual function that are particularly important for real world tasks such as reading, driving, walking, balancing, and navigating spatial environments.(Elliott, 2017; Pelli & Bex, 2013).

While visual acuity is the most commonly assessed parameter in clinical practice, it represents only a limited aspect of visual performance specifically, the ability to resolve fine details under high-contrast conditions. Contrast sensitivity, on the other hand, provides a more comprehensive measure of visual function by evaluating the ability to detect low-contrast stimuli at various spatial frequencies (Zimmerman et al, 2011). This function becomes especially crucial in low-light or high-glare environments, where standard acuity may remain unaffected. Studies have shown that contrast sensitivity is impaired not only in ocular disorders like cataracts, glaucoma, dry eye, and myopia, but also in systemic and neurological conditions such as diabetes, multiple sclerosis, and cerebral lesions. Furthermore, some medications can cause contrast sensitivity loss. Thus, contrast sensitivity has become a standard measure in clinical trials evaluating intraocular lenses, refractive surgeries, and pharmacological interventions for age-related visual decline.(Pelli & Bex, 2013).

Depth perception is another vital function that enables us to perceive the three-dimensional structure of the environment and judge spatial relationships accurately. While both monocular and binocular cues contribute to depth perception, it is typically more accurate when binocular vision is intact. Monocular cues include pictorial depth, motion parallax, and

accommodation, whereas binocular cues consist of convergence and stereopsis with the latter resulting from horizontal disparity between retinal images (Schwartz, 2010). Stereopsis arises when disparate retinal images from both eyes are fused into a single percept, giving rise to the sensation of depth (Nabie *et al.,* 2019). However, refractive anomalies, particularly anisometropia, uncompensated ametropia, and strabismus, can impair stereopsis and compromise depth perception (Fielder & Moseley, 1996).

Two of the most common refractive errors; myopia and hyperopia can may affect contrast sensitivity and stereopsis both in their uncorrected and corrected states. Myopia is a refractive error with increased prevalence globally ,where parallel light rays from distant objects focus in front of the retina due to excessive axial elongation of the eye or increased corneal/lenticular curvature resulting in blurred distance vision, while near vision remains clear. Genetics, prolonged near work, environmental factors as well as limited time spent outdoors, especially amongst children and adolescents are factors which play a role in myopia development and progression (Morgan et al, 2012). In contrast, hyperopia is a multifactorial refractive error resulting from a reduced axial length or a reduction in the curvature or refractive power of the eye's refractive components causing light rays to focus behind the retina when the eye is at rest thereby affect both distance and near vision, but symptoms are more commonly reported during near tasks, especially in children and older adults with reduced accommodative ability. Hyperopia is largely considered to be hereditary, with minimal influence from environmental factors (Benjamin,2006).

This study aims to compare contrast sensitivity and depth perception between myopes and hyperopes, providing insights into how refractive errors impact functional vision beyond standard acuity measurements. Understanding these differences could have implications for clinical vision correction strategies, occupational requirements, and low-vision rehabilitation.

1.1 BACKGROUND INFORMATION

1.1.1 CONTRAST SENSITIVITY IN VISION

Contrast sensitivity a critical aspect of vision is the ability to detect luminance differences between an object and its background, particularly under conditions where these differences are subtle. Unlike visual acuity, which measures the smallest detail that can be resolved under high contrast conditions. Contrast sensitivity evaluates the visual system's performance across a spectrum of contrast levels and spatial frequencies, making it a far more sensitive and ecologically valid indicator of functional vision (Rosa and Aleci.,2022).

Contrast sensitivity is central to many aspects of daily life. Tasks such as navigating dimly lit environments, driving at night, reading under variable lighting, facial recognition, and detecting low-contrast edges rely heavily on the ability to perceive contrast rather than sharpness alone. Traditional visual acuity assessments often fail to predict performance in these real-world scenarios, making contrast sensitivity a crucial complement to standard clinical testing (Elliott & Situ.,1998). For this reason, contrast sensitivity has become an essential parameter in both clinical research and practical ophthalmology, offering a more comprehensive understanding of visual performance in patients with subtle or non-specific visual complaints.

Functionally, contrast sensitivity is mediated by the magnocellular and parvocellular pathways in the visual system. The magnocellular pathway processes low spatial frequency, high temporal frequency, and motion-related information, while the parvocellular pathway is tuned to high spatial frequency, low temporal frequency, and fine detail. Disruption in either of these pathways can result in contrast sensitivity deficits, even in the absence of measurable acuity loss (Jindra & Zemon.,1989). This dual channel processing architecture provides a

framework for understanding how contrast perception may be selectively impaired under different physiological or pathological conditions.

1.1.1.1 THEORETICAL FRAMEWORK OF CONTRAST SENSITIVITY

The concept of the contrast sensitivity function (CSF) is one of the foundational frameworks for understanding how the visual system responds to spatial detail. In their work, F. W. Campbell and J. G. Robson (1968) showed that visual sensitivity is not uniform across spatial frequencies, rather it follows a band pass form, with maximal sensitivity at intermediate frequencies i.e around 3-5 cycles per degree and decreasing sensitivity at both lower and higher frequencies. Their findings supported the notion that the human visual system comprises multiple spatial frequency "channels," each tuned to a specific band of frequencies, and that the overall contrast sensitivity function reflects the envelope of these channels. Because the contrast sensitivity function spans a range of spatial frequencies rather than focusing exclusively on the high-frequency cutoff measured by standard visual acuity, it offers a richer psychophysical metric of how the visual system encodes both fine details and broader contours. Indeed, subsequent work (Owsley & Sloane.,1987) has affirmed that contrast sensitivity adds predictive power beyond acuity alone when one is interested in real-world functional vision.

Building on the contrast sensitivity function, the multiple-channels framework proposes that the visual system processes spatial information via a collection of independent neural pathways, each tuned to a particular band of spatial frequencies. Campbell and Robson (1968) originally argued for such channels based on psychophysical contrast sensitivity data, and later authors extended this by linking them to populations of cortical neurons whose receptive fields are optimally sensitive to specific spatial frequencies and orientations. More recently, electrophysiological evidence confirms that neurons in early visual cortex such as primary

visual cortex, V1 act as spatial frequency filters; each neuron reaches its maximal response at a particular spatial frequency and orientation of grating stimuli (Zhou *et al.,* 2021). Functionally, this framework explains why visual disorders affecting retina or cortical input may produce selective losses of sensitivity at certain frequency bands, even when standard acuity remains intact.

Another important framework is based on the division of labor between the magnocellular (M) and parvocellular (P) pathways of the visual system.The visual system can be functionally divided into two primary post-retinal pathways that perform distinct but complementary roles in visual processing. The magnocellular (M) pathway, originating from retinal parasol ganglion cells, is sensitive to low spatial frequencies, high temporal frequencies, and motion-related visual information. Conversely, the parvocellular (P) pathway, which arises from midget ganglion cells, exhibits greater sensitivity to high spatial frequencies, low temporal frequencies, and fine spatial detail (Ichhpujani & Thakur, 2024). This anatomical and physiological distinction provides a robust framework for explaining the shape of the contrast sensitivity function (CSF). Specifically, reductions in M-pathway activity are associated with diminished sensitivity to low-frequency contrast, while P-pathway dysfunction predominantly affects sensitivity to higher spatial frequencies (Cao, Zele, Pokorny, & Lee, 2011). Clinically, this model is valuable for interpreting contrast sensitivity losses in conditions such as optic neuritis, glaucoma, and other neuro-ophthalmic disorders, where selective vulnerability of one pathway over the other has been observed (Ichhpujani & Thakur, 2024; Cao *et al.,* 2011).

Among the established tools, the Pelli-Robson Contrast Sensitivity Chart remains one of the most widely used. It presents letters of decreasing contrast but constant spatial frequency, thus primarily targeting the parvocellular system, which mediates fine detail and high spatial

frequency processing (Pelli & Robson, 1988). However, it provides limited information about lower spatial frequency performance typically governed by the magnocellular pathway. To address this, spatial frequency specific tests such as the CSV-1000E or Vistech VCTS 6500 utilize sinusoidal gratings of varying spatial frequencies and contrasts, enabling clinicians to plot the contrast sensitivity function (CSF) directly. This approach provides a broader assessment of both M- and P-pathway sensitivity, and has been employed extensively in research on glaucoma, diabetic retinopathy, and optic neuritis, where selective pathway deficits have been observed (Cao, Zele, Pokorny, & Lee, 2011).

More recently, web-based and digital contrast sensitivity tools have expanded accessibility and precision in testing. The Spaeth/Richman Contrast Sensitivity (SPARCS) test, for instance, evaluates both central and peripheral contrast sensitivity using a computer interface. This feature allows for simultaneous assessment of magnocellular-dominated peripheral regions and parvocellular-dominated central vision. Ichhpujani and Thakur (2024) highlighted that SPARCS demonstrates good reproducibility, portability, and strong correlation with standard chart-based measures, making it a valuable addition to clinical and tele-optometry practice. Functionally, reduced low-frequency contrast sensitivity detected via these tools may suggest magnocellular pathway impairment, as seen in optic neuritis and glaucoma, whereas diminished high-frequency sensitivity often reflects parvocellular dysfunction, common in macular diseases and early diabetic retinopathy. Thus, by measuring contrast sensitivity across multiple spatial frequencies, clinicians can infer the relative contribution and health of each visual pathway, enhancing diagnostic precision and functional assessment.

The framework of Signal Detection Theory (SDT) positions contrast sensitivity assessment as a quantification of the observer's ability to discriminate a visual signal i.e a contrast

modulation from internal neural noise rather than as a purely deterministic threshold. From the SDT perspective, the detection threshold is determined not only by the physical contrast of the stimulus but also by the observer's internal noise level and decision criterion (Burgess, 2018). In practical optometric terms, this means that what we register as a "contrast threshold" is really the point at which the signal-to-noise ratio (SNR) in the visual system supports a specified level of perceptual certainty (e.g., a 75% correct response rather than simply the minimal visible contrast.

More recent psychophysical work emphasizes that contrast sensitivity charts and grating-based tests implicitly rely on signal detection theory constructs; the observer's response criteria, internal noise fluctuations, and external stimulus parameters all interact to determine measured sensitivity (Rosa *et al.,* 2022). Moreover, adaptive testing methods used in clinical contrast sensitivity assessment like computerized threshold leverage signal detection theory by adjusting stimulus contrast based on previous responses to converge efficiently on the threshold associated with a fixed d′ value (Pelli, 2013). From an optometric viewpoint, this means that when we interpret a contrast sensitivity value in a patient, we should recognize that it integrates both optical/retinal input and neural-decision variability. Thus, reduced contrast sensitivity in a given spatial frequency band may reflect elevated internal noise, lowered signal gain, or a shift in decision criteria factors that can be influenced by refractive error, media opacity, retinal disease or neural pathway dysfunction.

1.1.1.2 FACTORS AFFECTING CONTRAST SENSITIVITY (CS)

The optical quality of the retinal image exerts a strong influence on contrast sensitivity. Even relatively small amounts of spherical defocus or uncorrected astigmatic blur can lead to marked reductions in the contrast sensitivity function (CSF) especially at higher spatial frequencies often before changes are detected in high-contrast visual acuity (Hasegawa et al,

2018). Also, when the pupil dilates under low light (mesopic) conditions, higher-order aberrations (HOAs) such as coma and spherical aberration become particularly detrimental. Studies using wavefront aberrometry and adaptive optics correction show that increased HOAs degrade contrast sensitivity more severely under mesopic lighting (Ishii *et al.,* 2009)

Pupil diameter plays a key role in determining contrast sensitivity by mediating a trade-off between diffraction and optical aberrations. Under photopic lighting, the pupil constricts, and diffraction becomes the limiting factor at the highest spatial frequencies, while higher order aberrations (HOAs) remain relatively low. In contrast, under low light conditions the pupil dilates and HOAs including spherical aberration and coma become more dominant, leading to a reduction in contrast sensitivity across low to mid spatial frequencies (Tsang & Yik-Chong., 2013). At the same time, intraocular light scatter produces a "veiling luminance" or disability glare which flattens the contrast sensitivity function even when high-contrast visual acuity remains normal (Maniglia *et al.,* 2018)**.**

In patients with Dry Eye Disease (DED), conventional visual acuity tests often remain within normal limits, yet contrast sensitivity (CS) frequently deteriorates. This decline is primarily attributable to tear film instability, which causes rapid fluctuations in the optical wavefront and elevated light scatter, particularly at mid spatial frequencies. As a result, patients may report blurred vision or visual fatigue despite maintaining normal high contrast acuity. Importantly, interventions such as lubricating drops, anti-inflammatory therapies, and scleral lens wear have demonstrated more robust improvements in contrast sensitivity than in standard acuity measures, underscoring contrast sensitivity as a more sensitive functional marker in DED (Puell *et al.,* 2006; Akin *et al.*,2006)**.**

Lens opacities like cataract degrade contrast sensitivity by increasing intraocula light scatter. Patients with early cataract may still retain 6/6 acuity but show reduced CS, especially under

glare (Elliott & Situ, 1998).. Post-cataract surgery, Contrast sensitivity generally improves, though the extent depends on Intraocular lens design. Numerous clinical comparisons find that multifocal IOL optics are more likely to reduce mesopic and low-contrast performance producing lower contrast sensitivity under dim or glare conditions, whereas monofocal and many modern extended depth of focus (EDOF) designs tend to preserve contrast sensitivity to a greater extent although these lenses trade some aspects of absolute image quality for an extended range of focus (Rodríguez-Galietero *et al.,* 2005; Pedrotti *et al.,* 2020).

Contrast sensitivity also serves as a sensitive functional marker for early retinal and optic nerve pathologies, including glaucoma, age-related macular degeneration (AMD), and diabetic retinopathy. Unlike visual acuity, which often remains normal until later stages of disease, contrast sensitivity can reveal subtle neural and vascular impairments before structural damage is clinically evident (Shoshani *et al.,* 2019). Even in the absence of significant optical changes, the aging process is associated with a gradual decline in contrast sensitivity due to combined optical and neural factors. Empirical studies demonstrate that older adults experience selective reductions at mid-spatial frequencies, a phenomenon attributed to age-related alterations in photoreceptor efficiency and cortical signal processing (Zhuang *et al.,* 2021). This decline explains why many older individuals report “washed-out” or low-contrast vision despite maintaining standard high-contrast visual acuity.

1.1.1.3 METHODS OF MEASURING CONTRAST SENSITIVITY

From a psychophysical standpoint, contrast sensitivity is typically evaluated using sinusoidal gratings that vary in contrast and spatial frequency. The results are plotted to produce a contrast sensitivity function (CSF), which graphically represents an individual's threshold for detecting contrast at various spatial scales. In a normally functioning visual system, the contrast sensitivity function exhibits an inverted U-shaped curve in which sensitivity is

highest at mid spatial frequencies and declines at both lower and higher frequencies. This curve offers a rich profile of visual performance that extends well beyond what can be gleaned from a single acuity measurement. In clinical applications, contrast sensitivity testing has evolved into a standard component of visual performance assessments.(Owsley., 2003). Other methods of measuring contrast sensitivity include:

1. Chart-Based Methods

The Pelli Robson chart consists of letters (optotypes) of fixed large size approximately equivalent to the 20/60 Snellen at 1m. The letters are arranged in groups of three with contrast decreasing by 0.15 log units for each successive triplet. Testing is usually performed monocularly and binocularly at 1m, under standardized luminance of approximately 85 cd/m². The patient reads letters aloud until they are unable to identify at least two of a triplet, the score is recorded as log contrast sensitivity. Pelli Robson primarily assesses mid-spatial frequency sensitivity, which is critical for mobility, face recognition, and real world function. It is widely used in clinical trials for cataract, glaucoma, and Afe related macular degeneration (Elliott, 2017). Testing contrast sensitivity using the Pelli Robson chart is quite easy with results having high repeatability. The limitations to this test are it's Insensitivity to high-spatial-frequency loss, which may lead to missing subtle changes in early ocular disease (Pesudovs *et al.,* 2004).

This Mars contrast sensitivity test is quite similar to Pelli Robson, but in a compact chart form about the size of a clipboard. Each letter decreases in contrast in 0.04 log unit steps, providing finer measurement. Testing is performed at 50 cm under controlled illumination and the patient reads letter by letter until unable to continue. The Mars test is particularly effective in monitoring progressive diseases like glaucoma, diabetic retinopathy and in low-vision clinics where small incremental changes are important (Thayaparan et al, 2007). The

Mars letter contrast sensitivity chart is Portable, highly sensitive to subtle contrast sensitivity deficits and uses a shorter testing distance when compared to the Pelli -Robson chart. It is also restricted to low and mid-spatial frequencies.

2. Grating-Based Methods

The Vistech contrast test system uses sine-wave gratings printed on circular patches, varying in spatial frequency (1.5, 3, 6, 12, 18 cpd) and contrast. Patients view the chart at 3 m, and for each patch, they must identify the orientation of the grating (vertical, right-tilted, left-tilted). Responses yield a contrast threshold at each spatial frequency, forming a contrast sensitivity function curve. This test is particularly useful in refractive surgery evaluations and lens performance testing. It allows detection of specific frequency domain deficits (Mena-Guevara *et al.*,2024). Patient's fatigue and guessing may reduce reliability, especially at low contrasts.

Contrast sensitivity vision 1000(CSV-1000)

The CSV-1000 is an electrically illukinated, wall-mounted device that presents sinusoidal grating patches at fixed spatial frequencies typically 3, 6, 12, 18 cycles/degree with progressively lower contrast across each column. At the standard testing distance, the patient identifies which patch contains the grating versus blank fields. Results yield a full contrast-l sensitivity function (CSF) across frequencies, under photopic and optionally mesopic or glare conditions. This test is widely used in clinical trials of cataract surgery, intra-ocular lenses, and refractive procedures (Choi *et al.,* 2022). It is valued for standardised luminance and reproducibility, although patient fatigue and guessing can reduce reliability at the lowest contrast levels.

3. Adaptive and digital methods (Quick Contrast sensitivity Function)

Modern computerised CSF tests use Bayesian adaptive algorithms to estimate an individual's contrast sensitivity profile in a shorter time of about 5 to 10 minutes. The qCSF method presents optotypes or gratings at varying contrast and spatial frequency, then computes parameters such as peak sensitivity, cut-off frequency and area under the log CSF (AULCSF). It shows greater sensitivity to subtle visual changes than chart methods and is increasingly used in research on amblyopia, diabetic retinopathy and age-related macular degeneration (Hou *et al.,* 2018; Xu *et al.,* 2022). Because these systems adjust dynamically, they reduce testing time and variability compared to traditional charts.

1.1.1.4 CLINICAL APPLICATIONS OF CONTRAST SENSITIVITY TESTING

The pioneering work of Arden (1978) emphasized the diagnostic potential of contrast sensitivity in detecting subtle visual deficits in patients whose acuity remains within normal limits. His research demonstrated that individuals suffering from ocular or neurological disturbances often exhibit reduced contrast sensitivity well before any degradation of high-contrast visual acuity becomes apparent. As such, contrast sensitivity testing has become particularly valuable in identifying early functional impairment in conditions like glaucoma, macular degeneration, optic neuritis, and diabetic retinopathy, where traditional measures may fall short (Arden, 1978)

Contrast sensitivity is often reduced in early lens opacity before visual acuity drops, especially at mid high spatial frequencies and under glare or mesopic conditions. This makes contrast sensitivity invaluable for counseling patients who "see 6/6 but don't see well," for IOL selection, and for documenting functional gain after surgery. Post-operaration comparisons routinely show contrast sensitivity recovery that better predicts night driving comfort than visual acuity alone (Cochener., 2016; Wood *et al.,* 2010).

Contrast sensitivity contributes uniquely to hazard detection, obstacle recognition in low luminance, and glare recovery. Adding contrast sensitivity to visual test before driving license are issued improves prediction of on road performance compared with acuity alone; older drivers with reduced contrast sensitivity show greater car crashes and self-reported night driving difficulty (Anstey *et al.*,2018).

Beyond perimetry, contrast sensitivity captures quality of vision loss that patients describe as "washed out" or "dim," and correlates with everyday function like reading and mobility. Spatial contrast sensitivity like the SPARCS is associated with binocular performance and can reflect functional impairment even when standard high-contrast acuity is near-normal. Incorporating contrast sensitivity assists with counseling and testing vision loss in glaucoma(Ekici *et al.,* 2015).

Even with 6/6 acuity, amblyopic eyes often show reduced contrast sensitivity especially at higher spatial frequencies aligning with real-world complaints like reading speed, crowding and low-contrast print. Contrast sensitivity helps set therapy goals and evaluate treatment response beyond lines on a chart (Balcer et al, 2017).

1.1.2. DEPTH PERCEPTION AND STEREOPSIS

Depth perception is the visual system's capacity to perceive the world in three dimensions and to judge the relative distances between objects. It is a critical function for navigating physical environments and performing tasks that require precise spatial judgments such as reading, driving, catching, or threading a needle. Central to depth perception is stereopsis, a binocular visual function that arises from the slight differences in the retinal images captured by each eye due to their horizontal separation. When the brain integrates these binocular disparities, a sense of depth emerges (Howard & Rogers, 2002).

Stereopsis represents the most refined form of binocular depth perception and is often considered the third and highest grade of binocular single vision (BSV), following simultaneous perception and fusion. According to (Ziarat et al, 2024), this function enables the brain to create a composite image with accurate spatial relationships, essential for tasks involving coordination between visual input and motor output, such as in surgery, sports, or mechanical operations. The importance of stereopsis becomes even more evident in professions and daily activities where precise depth judgments are necessary. While monocular cues such as motion parallax, linear perspective, and size constancy can support some level of depth perception, these cues lack the accuracy and immediacy of binocular information. Binocular depth cues, such as convergence and retinal disparity, offer precise and consistent spatial information, making stereopsis the gold standard for measuring high-fidelity depth perception (Goldstein, 2002).

1.1.2.1 THEORETICAL FRAMEWORK OF DEPTH PERCEPTION

The images projected onto our two retinas are essentially two-dimensional, humans perceive the world in three dimensions. This is possible because the visual system extracts depth information from various cues present in the retinal images. One of the most important cues is binocular disparity, which refers to the slight positional difference between the two retinal images of the same point in space, a consequence of the lateral separation of the eyes and their different vantage points. The physiological foundations of depth perception are rooted in the study of binocular vision and the neural mechanisms that enable the brain to extract three-dimensional structure from two-dimensional retinal images.(Howard and Rogers., 2012)

Bishop and Pettigrew (1986) advanced the understanding of binocular vision by detailing how disparity sensitive neurons are organized in the visual cortex. They demonstrated that many neurons in the primary visual cortex (V1) exhibit binocular interactions, responding

preferentially to stimuli presented to both eyes rather than to monocular input alone. Importantly, they showed that these neurons are tuned to specific ranges of disparity, meaning that they respond selectively when the images presented to the two eyes are offset by particular amounts. This selectivity allows the visual system to encode relative depth at the level of neural populations. Their work provided evidence that binocular disparity is represented early in the cortical processing stream and that the tuning properties of these neurons are fundamental to depth perception.

Extending this work, Ohzawa, DeAngelis, and Freeman (1990) provided direct evidence that neurons in the visual cortex are ideally suited as disparity detectors. Using electrophysiological recordings in cat visual cortex, they demonstrated that disparity-selective neurons exhibit tuning functions that align closely with the requirements of stereoscopic depth discrimination

Marr (1982) described vision as a sequence of representational stages. At the most basic level, the primal sketch encodes edges, contrasts, and basic intensity changes, which serve as the foundation for identifying structural elements within the image. This is followed by the 2½-D sketch, a representation that incorporates surface orientation and depth information relative to the observer's point of view. Crucially, depth here is not yet represented in full object-centered coordinates but rather as how surfaces are arranged in space with respect to the viewer. Finally, the 3-D model representation organizes this information into a stable, volumetric description of objects and their spatial relationships, independent of the observer's viewpoint.

Marr emphasized that for the brain to compute disparity effectively, it must first solve the correspondence problem, that is, determining which features in the left and right retinal images correspond to the same point in the external environment. Computational algorithms,

he proposed, must operate on features such as edges and textures extracted in the primal sketch to match corresponding points across the two eyes and then compute disparity maps.

1.1.2.2. DEVELOPMENT OF DEPTH PERCEPTION

Newborns are birthed with a functioning but immature visual system; visual acuity, contrast sensitivity and binocular coordination are all severely limited early on (Horwood & Riddell, 2019). During the first months, infants rely heavily on monocular cues like motion parallax and interposition to form rudimentary judgments of relative distance (Yang, 2020).

Between approximately 3 and 5 months of age, electrophysiological and behavioural studies show that sensitivity to horizontal binocular disparity, the basis of stereopsis, becomes measurable (Norcia *et al.,* 2017). By around 5 to 7 months, many infants demonstrate coarse stereopsis (large disparities) and basic binocular fusion, although fine-disparity sensitivity (small thresholds) continues to mature into early childhood (Giaschi, Narasimhan, Solski & Wilcox, 2013).

Parallel to binocular development, improvements in monocular pictorial cue sensitivity such as texture gradients, linear perspective and relative size also emerge, typically becoming reliable around 5 to 7 months, although responses prior to this are variable and may reflect lower-level stimulus differences rather than true depth processing (Kavšek, 2013).

The classic “visual cliff” paradigm shows that by about 6 months, infants begin to avoid perceived drop offs, suggesting that depth perception is sufficiently functional to guide locomotor behaviour (Adolph & Kretch, 2012). Moreover, the onset of locomotor experience

(crawling, cruising) appears to refine depth-cue weighting and spatial judgment (Ionta, Gassert & Blanke, 2021).

1.1.2.3 CUES OF DEPTH PERCEPTION

Depth perception arises from the integration of multiple visual cues, broadly divided into binocular cues—those requiring both eyes—and monocular cues, which function with only one eye and thus become especially critical when binocular vision is compromised (O'Connor, 2018).

Monocular Cues

i. Pictorial Cues: These are static cues that the visual system extracts from a single still image and are utilized in paintings, photographs or real-world 3D scenes. Key examples include:

Occlusion (interposition): When one object partly hides another, the occluding object is interpreted as being nearer. This cue provides ordinal depth information (near/far ordering) and remains reliable even in the absence of stereopsis (Hickton, 2020).

Relative size: When two objects are known (or assumed) to have similar real-world size, the one producing the smaller retinal image is perceived as farther away (Yoo, 2023).

Familiar size: The observer's knowledge of an object's typical size allows depth inference in isolation for example recognising a person or car and judging its distance accordingly (Palmer, 1999).

Linear perspective: Parallel lines converging toward a vanishing point signal increasing depth such as railway tracks narrowing toward the horizon. The resulting illusion e.g., the

Ponzo illusion demonstrates how perspective cues influence size and depth judgments (Hickton, 2020).

Texture gradients: Surface texture becomes finer and denser as it recedes; the visual system interprets this change in spatial frequency as an indicator of depth (Tsutsui *et al.,* 2002).

Aerial perspective: Distant objects appear lower in contrast, slightly bluish or hazy due to atmospheric scatter. this reduction in luminance and saturation signals increased distance (O'Shea *et al.,* 1994).

Shading and shadows: Local shading cues convey surface orientation via the "light-from-above" assumption while cast shadows define object relationships in depth; manipulations of shadow placement yield predictable depth shifts (Wagemans *et al.,* 2010).

ii. Motion-based Monocular Cues

Motion parallax: As the observer moves laterally, nearer objects shift more rapidly across the retina than farther ones. Under appropriate conditions, motion parallax can approach stereopsis in precision and thus becomes a critical depth cue, especially for monocular viewing (Hibbard, 2025).

iii. Oculomotor Monocular Cues

Accommodation: The change in lens focus when viewing near objects gives a cue to their distance. Although weaker in adults (due to reduced accommodative amplitude), it contributes to depth perception.

Pictorial blur: Blur gradients associated with depth (objects out of focus appear blurrier) can serve as a depth cue, especially when combined with other cues (Hibbard,2025)..

Binocular Cues

1. Retinal horizontal disparity: When both eyes fixate on a point, an object located nearer or farther produces slightly different image positions on each retina. The brain interprets this retinal disparity as depth. Indeed, binocular disparity is widely recognised as the primary cue to stereopsis and is tightly linked to fine depth discrimination (Li, 2025).

2. Vergence and convergence: When an object approaches or recedes, the eyes moves inward or outward (vergence) to maintain single vision. The motor demand and corresponding kinesthetic signals serve as oculomotor depth cues, particularly effective in near-space(Linton, 2019).

1.1.2.4 METHODS OF MEASURING DEPTH PERCEPTION

The assessment of depth perception involves a range of clinical, psychophysical, and neurophysiological techniques designed to quantify stereoacuity which is the smallest binocular disparity an observer can detect. Stereoacuity serves as a key indicator of binocular visual function, reflecting both optical quality and cortical integration of disparity signals. Normal thresholds are approximately 20 seconds of arc, whereas values above 40 arcseconds indicate reduced stereopsis or abnormal binocular interaction (Ziarat *et al.,* 2024).

1. Clinical Stereoacuity Tests

Clinical stereotests provide rapid, cost-effective, and practical means of evaluating stereopsis in routine optometric and ophthalmic examinations. They are commonly applied in screening for strabismus, amblyopia, and refractive anomalies, particularly in pediatric and low-vision populations (O'Connor *et al.,* 2010).

Titmus Fly Test utilizes polarized vectographs to present large disparity stimuli (up to 3000 arcsec). It provides a gross assessment of stereopsis and is commonly used in pediatric settings. However, the test may be influenced by monocular cues and therefore lacks precision in detecting subtle stereo deficits (Yamada *et al.,* 2008).

Randot Stereotest employs random-dot patterns with disparity ranges from 500 to 20 arcsec, reducing monocular cue interference and offering finer stereoacuity measurement than Titmus Fly (Biddle *et al.,* 2019). Modern digital adaptations allow standardized luminance and automated scoring.

TNO Stereotest uses red green anaglyph random dot stereograms presented through color filters, effectively eliminating monocular cues. It covers a wide disparity range but may be unsuitable for individuals with color vision anomalies (Biddle *et al.*,2019).

Frisby Stereotest consists of transparent plates containing random-dot patterns printed at varying thicknesses, producing real disparity without filters or glasses. It is especially useful in pediatric optometric practice and provides accurate cue free stereo assessment (Bohr & Read, 2013).

Lang Stereotest incorporates cylindrical gratings embedded in a card to present disparity stimuli without special glasses, making it suitable for preverbal children or uncooperative patients (Lang, 1983).

2. Psychophysical Laboratory Methods

Psychophysical approaches are employed in experimental and research contexts to isolate and quantify specific binocular mechanisms with high precision. These methods require active participation and are not typically used in clinical environments.

Random Dot Stereograms (RDS) was introduced by Julesz (1971), RDS stimuli remove monocular depth cues, isolating true binocular disparity detection. Stereoacuity thresholds are determined using forced-choice paradigms, providing a gold standard for disparity processing research (Howard & Rogers, 2012).

Disparity Tuning Functions:

By systematically varying disparity magnitudes, researchers can map disparity sensitivity functions, illustrating how stereopsis changes with depth magnitude and eccentricity (Cormack *et al.,* 2017).

Motion-in-Depth Paradigms:

These assess dynamic depth perception using changing disparity or interocular velocity differenc cues, critical for real-world motion tasks such as driving or sports (Nefs *et al.,* 2010).

Vergence-Based Tasks:

Depth judgments are derived from ocular convergence or divergence responses, often quantified with infrared eye-tracking systems to study vergence control and fusional limits (Hussain *et al.,* 2023).

3. Electrophysiological and Imaging Methods

These objective methods are invaluable for evaluating infants, non-verbal patients, or subjects unable to perform psychophysical tasks. They directly measure cortical responses to disparity stimuli.

Visual Evoked Potentials (VEPs):

Disparity specific Visual evoked potentials can be recorded in response to dynamic random dot stereograms, providing an objective measure of cortical stereopsis. Disparity-sensitive responses emerge as early as three months of age (Dmochowsky *et al.,* 2017).

1.1.2.5 CLINICAL AND FUNCTIONAL APPLICATION OF DEPTH PERCEPTION

Clinically,One of the most important applications of depth perception lies in the diagnosis and management of binocular vision disorders this enabling the needed interventions. It also guides surgical outcomes and it is a key market for visual rehabilitation(Birch.,2013)

Functionally, depth perception is indispensable in activities of daily living. Tasks such as walking down stairs, pouring liquid into a cup, or threading a needle require precise depth judgments. In mobility, the ability to detect changes in terrain and avoid obstacles depends heavily on binocular and monocular depth cues (Levi, 2015).

Driving represents one of the most safety critical applications of depth perception. Tasks such as maintaining lane position, judging vehicle distance, overtaking, and night navigation depend on accurate interpretation of motion and disparity cues. Impaired depth perception has been linked to increased driving errors, underscoring its importance in road safety (Wood *et al.,* 2012; Wood, Chaparro, Carberry, & Chu, 2010).

In sports, depth perception supports accurate timing and spatial prediction. Athletes in ball related disciplines like tennis or basketball generally exhibit superior binocular coordination and dynamic stereopsis compared with non-athletes, contributing to faster visuomotor responses (Presta *et al.,* 2021). These visual advantages are trainable, emphasizing the role of perceptual learning in high-performance environments.

Depth perception is equally crucial in precision professions such as microsurgery, dentistry, and aviation. Three-dimensional visualization enhances spatial awareness and fine motor

control. Studies comparing stereoscopic and high-definition two-dimensional systems consistently report greater accuracy and reduced task time under true stereo viewing (Gietzelt *et al.,* 2022; Amiri *et al.,* 2024). Consequently, medical and technical training now commonly incorporate stereoscopic simulators to improve hand eye coordination.

From a developmental perspective, depth perception facilitates visuomotor learning in childhood. Deficits in stereopsis, often secondary to amblyopia or strabismus, can delay hand eye coordination and impact educational performance (Holmes & Clarke, 2006; Levi, 2015). Early detection and binocular therapy improve functional outcomes and quality of life.

In practical terms, reduced depth perception correlates with slower reaction times, decreased task precision, and greater difficulty in navigation and object interaction. Evidence from vision science, sports medicine, and clinical optometry underscores that depth perception is an essential visual function influencing safety, performance, and independence (Wood *et al.,* 2012; Presta *et al.,* 2021; Amiri *et al.,* 2024).

1.1.3 MYOPIA

Myopia also known as nearsightedness is a refractive error in which parallel rays of light from distant objects focuses anterior to the retina when accommodation is relaxed, producing reduced distance vision while near vision is relatively spared. In most cases the refractive error reflects axial elongation of the globe and less commonly results from excessive corneal curvature or lenticular power. The condition is therefore both optical and structural, with implications that extend beyond simple spectacle correction. (Morgan *et al.,* 2012). The etiology of myopia is multifactorial, involving complex interactions between genetic, anatomical, and environmental factors.(Morgan *et al.,* 2012).

1.1.3.1 EPIDEMIOLOGY OF MYOPIA

Myopia prevalence has risen markedly worldwide over recent decades and is now a major public health concern. Landmark global modelling estimated that by 2050 roughly half of the world's population may be myopic with approximately 10% highly myopic. More recent systematic reviews of children and adolescents confirm continuing increases, especially in urban East and Southeast Asia (Holden *et al.,* 2016; Pan *et al.,* 2025). The recent pooled data show prevalence rising from approximately 24% in 1990s to approximately 36% around 2020 to 2023 in children/adolescents, with projections to approximately 40% by mid century. Early onset in school age children has become common, increasing lifetime risk of progression and complications. (Pan *et al.,* 2025).

1.1.3.2 CLASSIFICATION OF MYOPIA

Myopia is usefully classified based on

1. Etiological classification

Axial myopia occuring due to excessive elongation of the globe.

Refractive myopia occurs due to abnormal curvature or refractive index of cornea or crystalline lens.

2. By degree of refractive error

Low myopia: ≤ -3.00 D

Moderate myopia: -3.00 to -6.00 D

High myopia: ≥ -6.00 D, associated with pathological risks (Tideman *et al.,* 2017).

3. Age of onset

Congenital myopia is usually present at birth and is non-progressive.

Juvenile-onset myopia develops during school years and it is often progressive.

Adult-onset myopia occurs after 20 years, often associated with occupational visual demands.

4. Pathological myopia: This is characterized by progressive elongation of the eye and degenerative changes such as posterior staphyloma, lacquer cracks, chorioretinal atrophy, and myopic macular degeneration (Ohno-Matsui et al, 2015).

1.1.3.3 CLINICAL SIGNS AND SYMPTOMS

Myopic patients typically present with progressive distance blur, squinting, and difficulty with activities requiring clear distance vision like driving, and reading from the. On examination there is reduced unaided distance acuity that corrects with minus lenses; retinoscopy commonly shows “against” motion. In high myopia fundus signs may include peripapillary atrophy, lattice degeneration, and progressive myopic maculopathy; axial length measurement and peripheral retinal evaluation are important in at-risk patients. (Morgan *et al.,* 2012; Tideman *et al.,* 2018).

1.1.3.4 MYOPIA PROGRESSION

Myopia progression mainly caused by axial elongation, most rapid in younger children. Longitudinal cohort and clinical trial data indicate typical annual axial growth of approximately 0.10–0.30 mm in progressing children. Also, myopic refractive change varies with age and ethnicity. Risk factors for faster progression include earlier onset, parental myopia, high near work demands and limited outdoor time (Chamberlain *et al.,* 2019; Lanca & Saw, 2020).

1.1.3.5 COMPLICATIONS OF MYOPIA

High and pathological myopia increase lifetime risk of sight threatening outcomes like retinal detachment, myopic macular degeneration, choroidal neovascularisation, glaucoma and early cataract. The structural stresses of axial elongation underlie these complications; hence public health concern is focused on reducing high myopia incidence through prevention and effective control in childhood. (Tedja *et al.,* 2019; Flaxman *et al.,* 2017).

1.1.3.6 MANAGEMENT OF MYOPIA

The two major goals for myopia management include:

1. correction of the refractive error to optimise vision

2. slow axial progression in children to reduce future risk.

Optical strategies include use of specialised soft contact lenses like MiSight and orthokeratology which reduce progression via peripheral defocus or corneal reshaping mechanisms; randomized trials show clinically meaningful slowing of myopia progression over multi year follow up. Spectacle lenses also aid in the correction of Myopia (Chamberlain *et al.,* 2019; Walline *et al.,* 2020).

Pharmacologic therapy like the use of low dose atropine (0.01%–0.05%) is the most widely adopted drug approach; large randomized and longitudinal studies show that atropine slows refractive progression and axial elongation with dose dependent effects and relatively favourable tolerability at low concentrations. (Chia *et al.,* 2012)

Environmental changes like Increasing outdoor time (evidence suggests ≥2 hours per day is protective) and reducing sustained near work are effective, low cost preventive measures supported by cohort and intervention data. (Lanca & Saw, 2023).

Refractive surgery (LASIK, PRK, phakic IOLs) corrects refractive error in adults but does not arrest axial elongation or eliminate the risk of posterior segment complications associated with long axial length (Walline *et al.,* 2020).

1.1.4 HYPEROPIA

Hyperopia also known as farsightedness is a refractive state in which parallel rays of light from a distant object are focused behind the retinal plane when accommodation is fully relaxed. This optical outcome results primarily from short axial length or less frequently reduced corneal or lenticular curvature, producing insufficient total refractive power of the eye (Majumdar, 2020; Marinescu *et al.,* 2023).

Clinically, hyperopic patients experience blurred near vision that can extend to distance blur in higher errors. Compensatory accommodation may maintain clarity temporarily but often leads to asthenopic symptoms, including eyestrain, headaches, and intermittent diplopia (Majumdar, 2020). In infants and young children, mild hyperopia is physiological; however, persistent or high hyperopia can interfere with binocular development, resulting in accommodative esotropia or amblyopia if uncorrected (Marinescu.,2023).

1.1.4.1 EPIDEMIOLOGY OF HYPEROPIA

The global distribution of hyperopia varies by age and ethnicity. Large meta analyses show that hyperopia ≥ +2.00 D affects approximately 3–7% of school-aged children, declining through adolescence as emmetropization occurs (Alrasheed *et al.,* 2023). In adulthood, prevalence rises again with age related reduction in accommodative amplitude, particularly beyond 40 years, due to crystalline lens changes (Hashemi *et al.,* 2018).

Geographically, European and North American populations exhibit higher hyperopia rates compared to East Asian cohorts where myopia predominates (Holden *et al.,* 2016). Although

the projected “myopia epidemic” is expected to dominate by 2050, hyperopia remains clinically relevant in aging populations, given its links with accommodative dysfunction and glaucoma risk (Marinescu *et al.,* 2023).

1.1.4.2 ETIOLOGY OF HYPEROPIA

The etiology of hyperopia is multifactorial, reflecting a combination of genetic, anatomical, and physiological influences (Flitcroft, 2014; Guggenheim *et al.,* 2022).

Genetic factors: Family aggregation and twin studies confirm a significant heritable component. Children of hyperopic parents have a higher probability of developing moderate to high hyperopia (Guggenheim *et al.,* 2022).

Anatomical contributors: Short axial length is the principal cause of optical hyperopia, while flatter corneal curvature, reduced lens thickness, or posterior lens displacement may contribute (Llorente *et al.,* 2004).

Age-related physiological change: Progressive lens sclerosis and reduced elasticity lead to age-related hyperopic shift, commonly termed presbyopic hyperopia, as accommodation declines (Flitcroft, 2014).

1.1.4.3 CLASSIFICATION OF HYPEROPIA

Hyperopia may be categorized using several clinical frameworks:

1. By Etiology

Axial hyperopia occuring due to short globe length.

Curvatural hyperopia resulting from flattened corneal or lenticular surfaces.

Index hyperopia associated with decreased refractive index of the crystalline lens.

Positional hyperopia caused by posterior displacement of the lens (Majumdar, 2020).

2. By Degree of Refractive Error

Low hyperopia: ≤ +2.00 D

Moderate hyperopia: +2.25 to +5.00 D

High hyperopia: ≥ +5.00 D, associated with higher risk of amblyopia and strabismus (Khurana, 2019).

3. By Functional State

Latent hyperopia masked by tonic accommodation and revealed with cycloplegic refraction.

Manifest hyperopia measurable without cycloplegia and may be facultative (compensated by accommodation) or absolute (cannot be compensated) (Ho, 2024).

4. By Age of Onset

Congenital hyperopia usually presents at birth presenting often with microphthalmia.

School-age hyperopia partially compensated by accommodation until near work demand increases.

Adult-onset hyperopia usually secondary to lenticular or surgical changes, such as post-LASIK overcorrection (Ang *et al.,* 2020).

1.1.4.4 CLINICAL SIGNS AND SYMPTOMS

Symptoms vary with age and refractive magnitude. Patients typically report blurred near vision, ocular fatigue, headaches, and intermittent diplopia after sustained near work.

Children may demonstrate avoidance of near tasks or poor academic performance due to visual discomfort (Khurana., 2019).

Signs include reduced unaided near visual acuity with relatively clear distance vision in mild cases, and a significant increase in hyperopic correction after cycloplegia, revealing latent error (Ho, 2024). In pediatric examinations, hyperopia may present with accommodative esotropia, bilateral amblyopia, or a crowded optic disc appearance in microphthalmic eyes (Majumdar, 2020).

1.1.4.5 COMPLICATIONS OF HYPEROPIA

Uncorrected or high hyperopia poses multiple visual and ocular risks:

Amblyopia and Strabismus: Hyperopia ≥ +4.50 D is strongly linked with bilateral refractive amblyopia and accommodative esotropia. Early cycloplegic detection and optical correction significantly reduce this risk (Klimek *et al.,* 2004; Lin *et al.,* 2024).

Angle-Closure Glaucoma: Eyes with shorter axial lengths and shallow anterior chambers are predisposed to primary angle-closure glaucoma; biometric assessment and gonioscopy are recommended in such patients (Day, 2013; Khazaeni, 2017).

1.1.4.6 MANAGEMENT OF HYPEROPIA

The primary goals in managing hyperopia are to achieve clear vision, prevent amblyopia, and minimize accommodative strain.

1. Optical Correction

Spectacles remain the first line correction, particularly in children at risk of strabismus. Contact lenses (rigid gas-permeable or soft) are suitable for older children and adults (Lin *et*

al., 2024). Full or partial correction is prescribed depending on symptomatology and binocular status.

2. Pharmacological and Amblyopia Management

Cycloplegic agents are diagnostic tools to reveal latent error. In amblyopia, treatment may include occlusion therapy, penalization, and vision therapy alongside optical correction (Holmes & Clarke, 2006).

3. Screening and Early Intervention

Routine preschool vision screening incorporating cycloplegic refraction is critical for early detection and prevention of amblyopia (Ho, 2024; Alrasheed *et al.,* 2023).

4. Refractive Surgery

Procedures such as LASIK, PRK, phakic intraocular lenses (IOLs), and refractive lens exchange are effective for low to moderate hyperopia correction in adults, though results are limited in very high hyperopia due to corneal biomechanical constraints and postoperative regression (Ang *et al.,* 2020).

1.2 STATEMENT OF PROBLEM

While visual acuity is commonly used to assess refractive errors such as myopia and hyperopia, it does not fully capture other important aspects of visual function like contrast sensitivity and depth perception. These visual functions are essential for daily activities such as reading, driving, and navigating through space. However, there is limited research comparing how myopia and hyperopia specifically affect contrast sensitivity and depth

perception. Understanding these differences is crucial for providing comprehensive eye care and optimizing visual performance in individuals with refractive errors. This study seeks to fill that gap by comparing contrast sensitivity and depth perception between myopes and hyperopes.

1.3. AIMS AND OBJECTIVES

1.3.1 AIM

To compare contrast sensitivity and depth perception between individuals with myopia and those with hyperopia, in order to determine how these refractive errors influence these aspects of visual function.

1.3.2 OBJECTIVES

1. To assess the contrast sensitivity levels in individuals with myopia and hyperopia.
2. To evaluate depth perception (stereopsis) in individuals with myopia and hyperopia.
3. To compare the differences in contrast sensitivity between myopes and hyperopes.
4. To compare the differences in depth perception between myopes and hyperopes.
5. To determine if the degree of refractive error (mild, moderate, high) has any correlation with contrast sensitivity and depth perception.

1.4. HYPOTHESIS/RESEARCH QUESTIONS

1.4.1 NULL HYPOTHESIS

There is no significant difference in contrast sensitivity or depth perception between myopes and hyperopes

1.4.2 RESEARCH QUESTIONS

1. How does contrast sensitivity differ between individuals with myopia and those with hyperopia?
2. Is there a significant difference in depth perception (stereopsis) between myopic and hyperopic individuals?
3. What is the relationship between the degree of refractive error (low, moderate, or high) and contrast sensitivity among myopes and hyperopes?
4. What is the relationship between the degree of refractive error and depth perception among myopes and hyperopes?
5. How does optical correction (with spectacles or contact lenses) influence contrast sensitivity and depth perception in myopic and hyperopic individuals?

1.5 SIGNIFICANCE OF STUDY

1. The study will enhance understanding of how myopia and hyperopia affect key aspects of visual function; contrast sensitivity and depth perception.
2. The study will aid eye care professionals in tailoring visual correction and rehabilitation strategies based on specific visual deficits associated with myopia or hyperopia.
3. The study will provide data that could be useful in fields like occupational vision screening, sports vision, and driving assessments.
4. The results may also serve as a foundation for public health policy and vision screening programs, particularly in populations where refractive errors are prevalent

but functional vision assessments like contrast sensitivity or stereopsis tests are rarely incorporated into standard screenings.

5. Academically, the study will contribute to the growing body of literature on functional vision assessment, emphasizing the importance of integrating psychophysical measures like contrast sensitivity and depth perception into routine optometric evaluation, especially in the context of rising global myopia prevalence.

1.6 DEFINITION OF TERMS

1. CONTRAST SENSITIVITY

Contrast sensitivity is the individual's ability to detect low-contrast objects of various sizes. Icontrast sensitivity (CS) provides useful information about functional or real-world vision that is not provided by VA including the likelihood of falling, control of balance, driving, motor vehicle crash involvement, reading, activities of daily living and perceived visual disability.

2. DEPTH PERCEPTION

Depth perception is the visual system's capacity to perceive the world in three dimensions and to judge the relative distances between objects. It is a critical function for navigating physical environments and performing tasks that require precise spatial judgments

3. MYOPIA

Myopia is a refractive error where parallel light rays from distant objects focus in front of the retina due to excessive axial elongation of the eye or increased corneal/lenticular curvature resulting in blurred distance vision, while near vision remains clear

4. HYPEROPIA

Hyperopia is a refractive error resulting from a reduced axial length or a reduction in the curvature or refractive power of the eye's refractive components causing light rays to focus behind the retina when the eye is at rest thereby affect both distance and near vision.

5. COMPARATIVE STUDY

A comparative study is a type of research design in which two or more groups, variables, or conditions are systematically compared to identify similarities, differences, and relationships. The primary aim is to evaluate how one group or condition differs from another under specific criteria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 RELATIONSHIP BETWEEN CONTRAST SENSITIVITY, MYOPIA AND HYPEROPIA

Thatte *et al,* (2022) conducted a large-scale cross-sectional study to evaluate the patterns of contrast sensitivity among myopic individuals who had 6/6 BCVA and no retinal pathology. The study included 500 literate participants aged 16–70 years and investigated contrast sensitivity in relation to multiple demographic and clinical variables such as age, sex, occupation, degree and duration of myopia, and presence of astigmatism. Using the Pelli–

Robson chart, the researchers classified myopia as low (< 3 D), moderate (3–6 D), and high (≥ 6 D), and graded contrast sensitivity as mild, moderate, or severe according to logMAR contrast thresholds. The results revealed that a substantial proportion of participants (82.2%) demonstrated mild contrast sensitivity decline, 15.8% had moderate decline, and 2.0% exhibited severe loss. Although mild reductions were observed across all age groups, there was no statistically significant relationship between age and contrast sensitivity ($p = 0.248$). However, the degree and duration of myopia were strongly associated with Contrast sensitivity performance ($p < 0.05$), indicating that higher refractive errors and longer durations of myopia corresponded with more severe contrast sentivity impairment. The presence of astigmatism further exacerbated this decline, particularly in cases of compound myopic astigmatism, which showed the greatest proportion of severe contrast loss ($p = 0.026$). This study emphasized that even in the absence of retinal disease, myopic individuals can experience a measurable decline in contrast perception, suggesting that standard acuity testing alone does not fully reflect functional visual performance (Thatte *et al.,* 2022).

Ilyas and Fatima (2022) explored contrast sensitivity among patients with varying degrees of hypermetropia, aiming to identify differences between low and high hyperopes. Their cross-sectional study, conducted at Mayo Hospital, Lahore, employed the Pelli Robson chart to evaluate monocular and binocular contrast sensitivity both with and without optical correction. Out of 54 participants, 34 were classified as low hypermetropes and 20 as high hypermetropes. The findings revealed that contrast sensitivity declined as the degree of hyperopia increased, though optical correction significantly improved scores ($p < 0.01$). In monocular assessments, low hyperopes generally maintained better contrast sensitivity than high hyperopes, and binocular performance exceeded monocular results across all participants. These outcomes highlight the compensatory role of binocular summation in

enhancing visual contrast perception, and reinforce that uncorrected hyperopia can significantly compromise visual quality even when visual acuity appears clinically normal (Ilyas & Fatima, 2022).

Similarly, Bilal *et al.* (2020) performed a comparative study of contrast sensitivity between myopic and hyperopic individuals using the Pelli Robson chart. Their results showed that hyperopic participants exhibited greater contrast sensitivity reduction compared to myopes. Mild to moderate myopes retained near normal contrast sensitivity, whereas severe myopia resulted in noticeable reductions. Interestingly, although hyperopes had more significant contrast sensitivity deficits overall, binocular testing still produced higher contrast sensitivity values compared to monocular assessments, confirming that binocular summation mitigates some contrast loss. Bilal *et al.* (2020) concluded that the optical defocus and aberrations inherent in both refractive states can impair contrast detection, but the effect is more pronounced in uncorrected hyperopia due to increased accommodative strain and reduced retinal image clarity.

Li *et al.* (2021) conducted a pioneering investigation into the combined effects of age and refractive error on contrast sensitivity using the quick contrast sensitivity function (qCSF) method in a population of Chinese adults. The study was designed to provide a more precise and efficient characterization of visual performance beyond conventional visual acuity assessments, recognizing that contrast sensitivity (CS) is a key determinant of real world visual function. The study included adult participants spanning a broad age range and representing varying degrees of refractive error, including emmetropia, myopia, and hyperopia. All subjects underwent best corrected visual acuity (BCVA) testing to ensure that optical blur was minimized, followed by qCSF assessment under standardized illumination conditions. The qCSF system generated detailed sensitivity profiles, providing parameters

such as area under the log CSF (AULCSF), peak sensitivity, and cutoff spatial frequency, each representing different aspects of visual quality. The results demonstrated a significant decline in contrast sensitivity with advancing age, particularly at higher spatial frequencies. This decline was consistent with age related reductions in optical clarity, retinal photoreceptor function, and cortical processing efficiency. Importantly, the study also found that refractive error type significantly affected contrast sensitivity, even after optical correction. Myopic individuals exhibited a relatively better performance at intermediate spatial frequencies, while hyperopic participants demonstrated lower CSF peaks and narrower sensitivity bandwidths, suggesting a more restricted range of spatial processing (Li *et al.,* 2021). These findings reinforce the notion that refractive correction alone does not fully restore normal visual quality, as neural and optical components of contrast processing are differentially influenced by the underlying refractive state. Furthermore, the study highlighted that age and refractive error exert independent yet interactive effects on contrast sensitivity. Older myopic individuals, for instance, showed a more pronounced decline in high frequency contrast sensitivity compared to younger counterparts, emphasizing that both biological aging and refractive status contribute to functional visual degradation.

Sun *et al.* (2016) conducted a pivotal study introducing and validating the Spaeth/Richman Contrast Sensitivity test (SPARCS), a digital, web-based tool developed to assess contrast sensitivity (CS) across both central and peripheral visual fields. The research sought to address the limitations of traditional paper based charts such as the Pelli Robson or Vistech systems, which typically measure central contrast sensitivity alone requiring controlled lighting environments. The study's objective was to evaluate the reliability, repeatability, and clinical applicability of SPARCS among individuals with corrected refractive errors, thereby determining its potential as a more comprehensive measure of visual function beyond

standard visual acuity. This cross-sectional study enrolled a cohort of patients with refractive errors whose visual acuity had been optimally corrected, ensuring that any differences in contrast perception were not confounded by uncorrected optical blur. Participants underwent contrast sensitivity assessment using the SPARCS platform. The results demonstrated that contrast sensitivity remains variable even in individuals with normal best corrected visual acuity (BCVA), indicating that visual acuity alone is an incomplete measure of functional vision. The SPARCS test exhibited high test retest reliability, with intraclass correlation coefficients (ICCs) above 0.90 across all field locations, confirming the method's consistency. The findings also revealed that contrast sensitivity declines gradually from the central to peripheral visual field, emphasizing the importance of evaluating peripheral vision when assessing overall visual function. Importantly, the study established that SPARCS was sensitive enough to detect subtle reductions in contrast performance even among individuals without retinal or optic nerve pathology, suggesting its clinical utility in detecting early functional visual impairment that conventional acuity tests might overlook (Sun *et al.,* 2016).

Kebede *et al.* (2023) conducted a clinic based comparative cross-sectional study at the Hawassa University Optometry Clinic to examine changes in contrast sensitivity before and after refractive correction among 162 patients with different refractive errors. Excluding participants with ocular or neurological pathology, the study employed a computerized Pelli Robson chart to obtain precise measurements at 1 m. Results demonstrated a significant improvement in mean contrast sensitivity following optical correction, from 1.29 ± 0.35 to 1.51 ± 0.38 log CS units ($p = 0.000$). Poor contrast sensitivity prevalence decreased from 23.5% to 9.7% after refraction. Among refractive groups, myopes exhibited the lowest pre- and post-correction CS values (1.45 ± 0.18 SD), followed by hyperopes (1.53 ± 0.07 SD) and astigmats (1.57 ± 0.19 SD). However, differences among the groups were statistically

insignificant after correction ($p > 0.05$), underscoring that appropriate optical correction substantially normalizes CS across refractive types. The study also identified an inverse relationship between age and CS (older participants having lower CS), while gender had no significant effect. These findings reaffirm the importance of accurate refractive correction in maintaining functional vision and preventing misinterpretation of CS deficits as retinal or neurological issues (Kebede *et al.,* 2023).

In a related investigation, Thatte *et al.* (2023) extended their earlier work by examining contrast sensitivity across different refractive error types, including myopia, hyperopia, and astigmatism. Enrolling 500 participants in the Department of Ophthalmology aged 10to 80 years with BCVA of 6/6, the study classified contrast sensitivity losses as mild, moderate, or severe. Approximately half the participants demonstrated mild contrast sensitivity decline (50%), while severe reduction was most prevalent among younger individuals ≤ 30 years (60.7%). Both the duration and type of refractive error significantly influenced contrast sensitivity outcomes. Patients with compound myopic astigmatism, the most prevalent refractive subtype (34.4%), experienced the greatest decline in contrast sensitivity, with 82 patients showing severe impairment. Conversely, simple hypermetropic astigmatism and simple hypermetropia displayed comparatively mild reductions. The authors emphasized that contrast sensitivity testing should complement visual acuity assessment in routine clinical practice since many patients with 6/6 VA still exhibited impaired CS (Thatte *et al.,* 2023).

Building upon this evidence, Shiqlabu *et al.* (2024) investigated the effects of varying refractive error severities on contrast sensitivity among 120 patients (240 eyes) aged 20–60 years. Participants were categorized into mild/moderate hyperopia, mild myopia, moderate myopia and severe myopia or hyperopia, as well as an emmetropic control group. Using cycloplegic refraction and the Pelli–Robson chart, the study found that severe myopia

(spherical equivalent > –10.00 D) was strongly associated with reduced contrast sensitivity even with full optical correction. These patients recorded mean contrast sensitivity values of 1.99 ± 0.34 log units, significantly lower than emmetropes and low to moderate myopes. In contrast, both mild and severe hyperopes exhibited relatively normal contrast sensitivity values, indicating that hyperopia without amblyopia may not necessarily compromise contrast processing. Furthermore, a negative correlation was identified between contrast sensitivity and best corrected visual acuity ($r = –0.566$, $p = 0.000$), while spherical equivalent correlated positively with contrast sensitivity ($r = 0.310$, $p = 0.000$). This confirmed that increasing myopic power contributes to functional contrast sensitivity deterioration, whereas hyperopia, when corrected early, tends to preserve visual contrast detection (Shiqlabu *et al.,* 2024).

2.2 REVIEW OF DEPTH PERCEPTION IN MYOPES AND HYPEROPES

Tilahun *et al.* (2021) investigated the relationship between refractive errors and stereopsis among patients attending the Optometry Clinic at Gondar University Hospital, Ethiopia. Their cross-sectional study involved 153 adults and assessed stereoacuity using the TNO stereo test following refractive correction. The study found that 46.4% of participants exhibited poor stereopsis before correction, which improved to 39.8% after correction. The improvement underscored the strong link between uncorrected refractive error and binocular dysfunction. Moreover, stereoacuity values ranged between 1.89 to 2.65 log arc seconds, and poorer stereopsis was significantly associated with reduced best corrected visual acuity, older age, and the type of refractive error. Hyperopic participants tended to have better stereopsis compared to myopes, suggesting that axial elongation and associated optical aberrations in myopia may contribute more substantially to depth perception deficits. Tilahun *et al.* concluded that stereopsis recovery following refraction emphasizes the critical role of optical

correction in maintaining binocular visual function and preventing long-term suppression or amblyopia.

Expanding upon these findings, Elamurugan *et al.* (2022) explored stereopsis among pediatric and adolescent populations with refractive errors in South India. The cross-sectional study enrolled 222 children aged 5–18 years and compared stereopsis across refractive groups using the Titmus Fly and Randot stereo tests. Astigmatism (60.4%) was the most common refractive error, followed by myopia (24.8%) and hyperopia (1.4%). Results revealed that spherical myopes exhibited better stereopsis than astigmats and anisometropes, while children with anisometropia greater than 1.5 D showed the poorest stereopsis, likely due to aniseikonia disrupting binocular fusion. Notably, hyperopic children demonstrated normal stereopsis in all cases, suggesting that mild to moderate hyperopia, when corrected, may not significantly impair depth perception. The Randot test detected finer gradations of stereopsis (400–20 arcsec) compared to the Titmus test (800-40 arcsec), supporting its use in clinical research. This study emphasized that, in children, early correction of refractive errors is crucial for developing normal binocular vision and preventing suppression or reduced depth perception (Elamurugan *et al.,* 2022).

Similarly, Sethi and Kashyap (2015) provided foundational insights into the influence of refractive errors on stereopsis in school aged children. Their study categorized refractive errors into spherical, cylindrical, and mixed types, and compared stereoacuity between isometropic and anisometropic groups. The findings indicated that anisometropic children (with ≥1.0 D interocular difference) had significantly poorer stereoacuity ($p = 0.04$) compared to isometropes, which was attributed to image size disparities between the eyes. Moreover, cylindrical and mixed refractive errors produced greater stereopsis deficits than spherical errors ($p < 0.01$). These results reinforced the notion that binocular imbalance

whether from refractive magnitude or meridional differences disrupts binocular summation, impairing fine depth discrimination (Sethi & Kashyap, 2015).

Yousefi *et al.* (2022) carried out a significant study examining how refractive error correction influences stereopsis. The research employed a cross-sectional experimental design involving individuals with varying degrees and types of refractive error. Participants underwent comprehensive ophthalmic examinations including refraction, best-corrected visual acuity (BCVA) assessment, and stereopsis testing. Stereopsis was measured using standard clinical stereoacuity tests, such as the Titmus fly test and Randot stereo test, both before and after refractive correction. By comparing pre- and post-correction results, the study aimed to evaluate how optical clarity affects binocular depth perception and to determine whether refractive error correction could restore normal stereopsis thresholds. Findings from Yousefi *et al.* (2022) demonstrated a significant improvement in stereopsis after refractive correction across all refractive error groups. Prior to correction, many participants exhibited subnormal stereoacuity, particularly those with uncorrected myopia or hyperopia, indicating that defocus and image blur can disrupt binocular correspondence between the two eyes. After optical correction whether through spectacles or contact lenses, stereoacuity improved markedly, showing that once retinal image clarity and size equality were restored, the visual cortex was able to integrate binocular information more effectively. These improvements were more pronounced in participants with mild to moderate refractive errors, while individuals with high ametropia showed partial recovery, suggesting that prolonged uncorrected blur may lead to binocular adaptation or suppression that takes time to reverse.

Joo and Choi (2023) conducted a study examining the impact of refractive error on stereopsis and fusion, two integral components of binocular vision that enable accurate depth perception. Their work focused on school aged children with reduced visual acuity caused by uncorrected

refractive errors, aiming to determine how visual clarity affects the development and integrity of binocular visual functions. The authors recruited a large cohort of children aged 6 to 12 years and assessed them for stereopsis, fusional ability, and refractive status. Stereopsis was evaluated using standardized clinical tests such as the Titmus Fly and Randot stereo tests, while fusion was assessed through Worth 4-dot and synoptophore testing. Participants were divided into groups based on the type and degree of refractive error; myopia, hyperopia, and astigmatism and compared against a control group of children with normal visual acuity and minimal refractive error. Results from Joo and Choi's (2023) study revealed that uncorrected refractive errors significantly impair both stereopsis and fusion, with the severity of impairment correlating with the magnitude of refractive error and degree of visual acuity loss. Myopic and hyperopic children demonstrated poorer stereoacuity thresholds and reduced fusion ranges compared to emmetropic peers. Interestingly, after full optical correction, there was a notable improvement in both stereopsis and fusion responses, although some children exhibited persistent deficits suggesting a period of visual adaptation or incomplete binocular recovery. These findings emphasize the sensitivity of binocular vision to optical quality and the importance of early detection and correction of refractive errors in preserving normal binocular development.

Ziarat *et al.* (2024) conducted a descriptive cross-sectional study at the University of Lahore Teaching Hospital to examine stereoacuity across myopic, hyperopic, and astigmatic individuals. The study recruited 145 participants aged 15–35 years, with stereopsis measured using the Random Dot Stereo test—a test designed to eliminate monocular cues. Stereoacuity was categorized as normal (≤20 arcsec), borderline (20–40 arcsec), or reduced (>40 arcsec). Of the 72 myopic participants, 75% demonstrated normal stereopsis, while 11% showed borderline and 14% exhibited reduced stereopsis. Among hyperopes (n = 18), 12 had normal

stereopsis, 4 borderline, and 2 reduced, whereas astigmatic participants exhibited the greatest proportion of reduced stereopsis (18%). Statistical analysis revealed a significant association between refractive error type and stereopsis ($p = 0.0267$). The findings suggested that while both myopia and hyperopia can impair stereopsis, astigmatism poses an even greater threat to fine binocular function due to meridional blur and inconsistent retinal image correspondence (Ziarat *et al.,* 2024).

2.3 RELATIONSHIP BETWEEN CONTRAST SENSITIVITY, DEPTH PERCEPTION AND REFRACTIVE ERRORS

Jamil *et al.* (2022) conducted a cross-sectional study to compare stereopsis and contrast sensitivity among individuals with myopic and hyperopic anisometropia. Sixty subjects were selected and divided into two equal groups: 30 patients with myopic anisometropia and 30 with hyperopic anisometropia. Anisometropia was defined as a minimum of 2.00 diopters interocular difference in spherical equivalent refractive error. All subjects underwent a complete ocular examination. Best corrected visual acuity (BCVA) of 6/6 or better in both eyes was required. Stereopsis was assessed using the Titmus Fly Stereotest, and contrast sensitivity was measured using the Mars Contrast Sensitivity chart. All tests were conducted under natural lighting conditions.The results showed no statistically significant difference in stereopsis between myopic and hyperopic anisometropes ($p = 0.11$). Mean stereopsis for myopic anisometropes was 916.6 ± 1173.5 seconds of arc, while that for hyperopic anisometropes was 460 ± 700 seconds of arc. Similarly, no statistically significant difference was found in contrast sensitivity between the two groups ($p = 0.22$). The contrast sensitivity for the right and left eyes in myopic anisometropes was 1.40 ± 0.31 and 1.45 ± 0.33, respectively; for hyperopic anisometropes, it was 1.52 ± 0.21 and 1.53 ± 0.18, respectively. The study concluded that although both contrast sensitivity and stereopsis were lower in

anisometropic individuals, there was no significant difference in the levels of impairment between those with myopic and hyperopic anisometropia. The authors recommended timely optical correction for anisometropic patients to minimize potential impacts on binocular vision.

2.4 GAPS IN THE LITERATURE

Despite various studies exploring the relationship between refractive errors and visual performance parameters such as contrast sensitivity and depth perception, significant research gaps remain in both methodological design and clinical interpretation. These gaps highlight the need for more comprehensive, controlled, and comparative investigations to better understand the functional implications of myopia and hyperopia beyond visual acuity assessment.

Most existing studies like Thatte *et al.,* 2022; Kebede *et al.,* 2023; Shiqlabu *et al.,* 2024) have primarily examined contrast sensitivity in myopic populations or in general refractive error cohorts without isolating and directly comparing myopic and hyperopic groups under identical testing conditions. Similarly, investigations focusing on hyperopia (Ilyas & Fatima, 2022) often lack a direct comparative framework with myopic counterparts. This absence of balanced comparative data limits the understanding of how these two common but distinct refractive conditions differentially affect visual processing mechanisms such as contrast discrimination and stereopsis.

A major limitation across the reviewed studies is the heterogeneity in test protocols, particularly concerning contrast sensitivity and stereopsis assessment tools. The Pelli Robson chart remains widely used, but it measures only mid-spatial frequencies, providing limited information on high and low spatial frequency performance that could reveal subtle

functional differences (Cerviño *et al.,* 2020). Few studies (e.g., Kebede *et al.,* 2023) employed digital or multi-frequency assessments such as the CSV-1000 or qCSF, which offer a more complete spatial frequency analysis. Similarly, stereoacuity measurements vary among studies using TNO, Randot, or Titmus Fly tests each with differing thresholds and susceptibility to monocular cues (Elamurugan *et al.,* 2022; Ziarat *et al.,* 2024). This inconsistency limits inter-study comparability and weakens the generalizability of findings.

Most available studies are hospital based or regional, with small to moderate sample sizes and limited ethnic or demographic diversity (Tilahun *et al.,* 2021; Elamurugan *et al.,* 2022). Given that visual performance metrics can vary with ethnicity, ocular morphology, and environmental exposure, the lack of population diversity restricts the applicability of results to broader populations. Additionally, many studies focus on younger adults, neglecting pediatric and presbyopic populations, in whom accommodative and neural factors may differentially influence contrast and stereopsis.

Existing literature is predominantly cross-sectional, offering only snapshots of visual performance across refractive categories. There is a notable scarcity of longitudinal studies evaluating how contrast sensitivity and stereopsis evolve with refractive progression or following optical interventions such as orthokeratology, contact lenses, or refractive surgery.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 RESEARCH DESIGN

The study utilized a comparative, cross-sectional study design.

3.2 RESEARCH LOCATION

The study was conducted at the Optometry teaching Clinic, University of Benin Campus located in Benin City, Edo state, Nigeria.

3.3 STUDY POPULATION

This study population comprised spectacle corrected myopes and hyperopes within the age limits of 18-37 in the University of Benin community, Benin City, Edo State who met the inclusion criteria.

3.4 SAMPLING TECHNIQUE/SAMPLE SIZE DETERMINATION

3.4.1 SAMPLING TECHNIQUE

The study employed a convenience/ purposive sampling technique to select participants from the University ofBenin. This method was chosen because it was practical and allowed ease of accessing persons who were available and willing to participate in the study. It allowed for efficient data collection within the study's time frame while ensuring adequate representation of the population.

3.4.2 SAMPLE SIZE DETERMINATION

To calculate sample size,data from the study Kebede et al (2023) will be used

The sample size will be determined by using the formula for comparing two independent means)

$$n = \frac{2(Z_{\alpha/2} + Z\beta)^2 \times \sigma^2}{d^2}$$

$Z_{\alpha/2}$ = is the critical value of the standard normal distribution at the given significance level (for $\alpha = 0.05$, $Z_{\alpha/2} = 1.96$)

Z_β = is the critical value of the standard normal distribution at the given power level (for 1-β = 0.80, = Z_β = 0.84).

Mean Contrast Sensitivity (LogCS)

Myopes: 1.45 ± 0.18

Hyperopes: 1.53 ± 0.07

The mean difference between groups(1.53- 1.45) is 0.08 LogCS.

Standard deviation (σ) = The pooled standard deviation calculated from the means is 0.136

The expected difference in means between the two groups d= mean difference/pooled standard deviation =0.08/0.136 =0.59 (moderate effect size)

$$n = \frac{(2(1.96 + 0.84) \times 0.136)^2}{0.08^2}$$

= 45.3

n ≈ 45

Considering a 10% non-participation rate (attrition rate)

0.1 x 45 = 4.5 ≈ 5

Final sample size = 45 + 5

= 50 participants per group (i.e 50 myopes and 50 hyperopes)

Altogether, we have 100 participants for this study.

3.5 MATERIALS

- Snellen chart
- Ophthalmoscope
- Retinoscope
- Trial lens box
- Meter rule
- Lensometer
- pelli Robson chart
- Stereoacuity chart (Lang II)
- Data recording sheet/consent form

FIGURE 3.1: PELLI ROBSON CONTRAST SENSITIVITY CHART

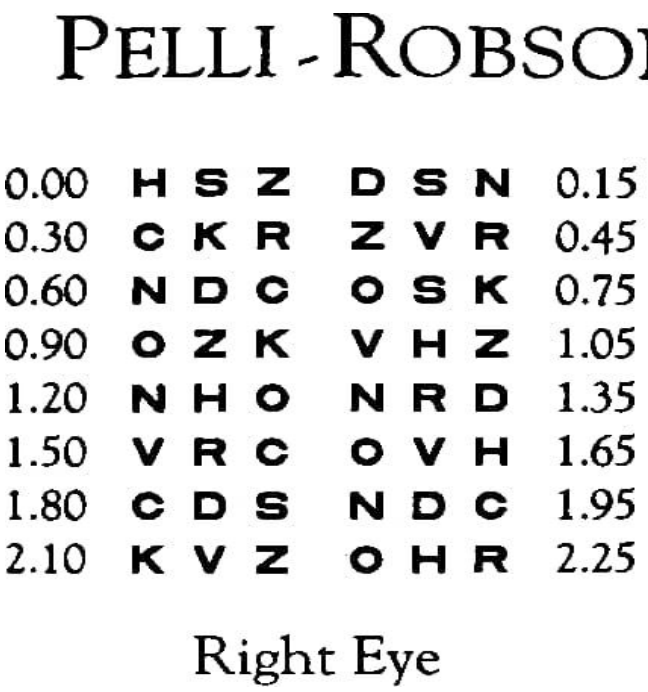

FIGURE 3.2: NORMAL VALUES FOR THE PELLI ROBSON CONTRAST SENSITIVITY CHART

FIGURE 3.3: LANG 2(II) STEREOTEST

3.6 INCLUSION CRITERIA/EXCLUSION CRITERIA

3.6.1 INCLUSION CRITERIA

1. Individuals diagnosed with myopia or hyperopia and corrected for the refractive errors

2. Individuals aged 18 to 37 years

3. Best corrected visual acuity of 6/6 (20/20) in both eyes.

4. Individuals with no history of ocular surgery or trauma.

5. Individuals willing to participate and provide informed consent.

3.6.2 EXCLUSION CRITERIA

1. Individuals with emmetropia (normal vision).

2. Presence of ocular diseases (e.g., cataract, glaucoma, macular degeneration).

3. Individuals with strabismus or any binocular vision anomaly affecting depth perception.

4. Individuals with history of systemic disease affecting vision (eg diabetes, hypertension).

5. Individuals with history of neurological disorders affecting vision.

6. Individuals Currently using medications known to affect visual function.

3.7 DESCRIPTION OF PROCEDURE

This study was carried out using 80 volunteer participants of the University of Benin community. Case history and other preliminary examinations were properly taken to ensure

that the subjects meet the inclusion criteria. The nature of the procedure was well explained to the subjects.

PRELIMINARY EXAMINATION

- Written consent and bio-data were obtained from all participants.
- Unaided and aided visual acuity test were carried out using Snellen chart monocularly and binocularly.
- External eye examination i.e penlight examination, shadow test, cover test and ocular motility test were done to rule out any ocular pathology and misalignment.
- Ophthalmoscopy were carried out to rule out any form of ocular infections, pathology and retinal diseases .
- The current prescription of participants who were refracted a year ago and less will be assessed using the lensometer.
- Retinoscopy and subjective refraction were carried out for participants who had been refracted over a year ago to get their accurate prescriptions.
- Retinoscopy and Subjective refraction were also done for participants who had an obvious refractive errors based on their complaints and visual acuity.

CONTRAST SENSITIVITY TEST

- Contrast sensitivity for each participant were assessed using the Pelli Robson chart in a properly illuminated room.

- The Pelli-Robson chart were placed at a distance of 1m from the patient at their eye-level.
- The contrast sensitivity test were done monocularly and bonocularly with and without the participants prescription.
- The participants were instructed to read the letters out aloud from the top left(highest contrast letters). The patient read the chart until they could no longer identify the letters.
- The end point of the contrast sensitivity test was when the patient made two or more errors in a group of three letter contrast with the same contrast level. The last correctly identified triplet determined the contrast sensitivity threshold.

DEPTH PERCEPTION TEST USING THE LANG II CHART

The Lang-Stereotest II is an orthoptic product for binocular diagnostics and screening of stereo vision disorders, for medical professionals. The test is used for rapid screening of stereo vision in all age groups from 6 months of age. The Lang stereo test ll has proven to be highly specific and highly sensitive for stereo vision. Thanks to the unique combination of random dots and lenticular, special glasses are not required and the gaze behaviour remains observable.

- Positioning myself holding the chart in front of the participant, so that their eye movements can be easily observed.
- The test plate was placed exactly at right angles at a distance of about 40 cm (16 inches).

- The participant will be asked if he/she sees something on the plate and watch the searching movements of his/her eyes.
- When a 3D object has been detected, ask the participants were asked to look for additional objects and also to describe them. The participants were also allowed to point at the figures and tell which of them sticks out the most.
- The results of the test were recorded as:

Positive: Correct localization and naming of all hidden objects, typically jumping eye movements from one object to the next. No further examination of stereoscopic vision is needed.

Negative: no object can be detected, and eye movements also do not indicate the recognition of the 3D objects. Eyes are scanning the test plate and then shift away from it.

Technical specifications of the Lang stereotest ll:

3D Objects and Disparities of Lang-Stereotest® II

ELEPHANT 600’’

TRUCK 400’’

MOON 200’’

STAR 200’’ (2D, always visible)

All results were recorded accordingly in the result sheet.

3.8 DATA ANALYSIS

The data obtained from this study was analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. A p-value < 0.05 was used to denote statistical The gathered data was entered into Microsoft Excel 2016 spreadsheet. The Statistical Package for the Social Sciences (SPSS), Version 25.0 (IBM Corp., Armonk, New York, USA), was then used to conduct statistical analysis. Descriptive statistics including frequency, mean, standard deviation, and percentages were utilized to analyze the data. Also, inferential analysis was performed to test relationships. To give a visual depiction of the data, the findings were presented using tables and figures such as column charts.

3.9 ETHICAL APPROVAL

Ethical approval for the study was obtained from the Research and Ethics Committee of the Department of Optometry, University of Benin. The REC approval number is EC/UBEN/LSC.OPT/25/143. Participants were provided with detailed information about the study, and only those who gave informed consent were included. To ensure anonymity, no personal identifying information was collected. Data were handled confidentially and used solely for research purposes. The study adhered to the principles of the Declaration of Helsinki to maintain the highest ethical standard.

3.10 LIMITATIONS OF STUDY

1. Sample Size and Demographic Scope: The study's sample size (n = 80) was adequate for preliminary comparative analysis but may limit the generalizability of the findings. Participants were largely young adults (mean age ≈ 20.5 years), representing a narrow age range hence the results may not fully reflect patterns in older or pediatric populations Future studies incorporating a broader age distribution could provide a more comprehensive understanding of age related changes in functional vision.

2. Time constraint: The original sample size for this study was 100 participants but this sample size could not be reached bas a result of limited time available to complete this study. Assessing more participants over a longer period of time would give more consistent results.

3. Convenience Sampling: Although the convenience sampling was deemed the most appropriate for this study, it may have potentially selection bias and limiting the representativeness of the sample thereby impacting the generalizability of the findings beyond the sampled population.

4. Instrument and Test Limitations: Contrast sensitivity was assessed using the Pelli Robson chart, which primarily measures low to mid spatial frequency contrast and may not capture higher spatial frequency deficits that could be more pronounced in myopia. Similarly, the depth perception assessment utilized a Lang stereopsis test, which was highly influenced by monocular cues and lacks the precision of newer computerized stereopsis tests. Thus, results might slightly overestimate functional stereopsis in some participants.

5. Accommodation and Uncorrected Hyperopia: The inclusion of young, accommodatively active hyperopes may have introduced a confounding factor, as their ability to compensate for blur through accommodation could artificially elevate unaided contrast sensitivity and stereopsis scores relative to myopes. Cycloplegic refraction was not performed prior to testing, which could have masked latent hyperopia or induced variable accommodative effort.

CHAPTER FOUR

4.0 RESULT AND DATA ANALYSIS

4.1 SOCIODEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

The study included 80 participants, consisting of 22 males (27.5%) and 58 females (72.5%), indicating a predominance of female participants. The age distribution ranged from 18 to 26 years, with most participants aged 20 years (23.8%) and 18 years (22.5%), followed by those aged 22 years (13.8%).

TABLE 1: SOCIODEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

Variables	Count (n)	Percent (%)
Gender		
Male	22	27.5%
Female	58	72.5%
Total	80	100.0%
Age (years)		
18	18	22.5%
19	12	15.0%
20	19	23.8%
21	6	7.5%
22	11	13.8%
23	7	8.8%
25	6	7.5%
26	1	1.3%
Total	80	100.0%

TABLE 2: MEAN AGE OF PARTICIPANTS

N	Mean (years)	Standard Deviation
80	20.46	2.15

The mean age of participants was 20.46 years (SD = 2.15), with ages ranging from 18 to 26 years.

4.2: CLINICAL AND VISUAL FUNCTION CHARACTERISTICS

Out of 80 participants, 48.8% had myopia while 51.2% had hypermetropia, indicating an almost even distribution of refractive errors in the study sample.

TABLE 3: FREQUENCY OF REFRACTIVE ERRORS

Refractive Error Type	Frequency	Percent (%)
Myopia	39	48.8
Hypermetropia	41	51.2
Total	80	100.0

From the data contained in Table 4, it is shown that the study population showed mild to moderate refractive errors, with slightly higher hypermetropia prevalence. Unaided visual functions were suboptimal across participants, as reflected in poorer visual acuity and moderate contrast sensitivity. However, with optical correction, both acuity and contrast sensitivity improved significantly, and depth perception values indicated better stereopsis, demonstrating the impact of proper refractive correction on visual performance.

For unaided vision, the mean spherical power for the right and left eyes was approximately -1.22 D and -1.20 D respectively, indicating a predominantly myopic sample. Average unaided visual acuity was poorer than normal (Mean LogMAR ≈ 0.25–0.39), suggesting reduced clarity without correction. Contrast sensitivity (M ≈ 1.79–1.97) and depth perception (M = 450.00 ± 166.88) were within typical functional ranges, though variability indicates differing visual capacities across participants.

TABLE 4: CLINICAL AND VISUAL FUNCTION CHARACTERISTICS (UNAIDED)

Variables	N	Minimum	Maximum	Mean ± SD
Right eye spherical lens prescription (D)	80	-10.50	1.75	-1.22 ± 2.42
Left eye spherical lens prescription (D)	80	-10.50	1.75	-1.20 ± 2.40
Unaided visual acuity – right eye (LogMAR)	80	-0.16	1.38	0.39 ± 0.47
Unaided visual acuity – left eye (LogMAR)	80	-0.16	1.30	0.34 ± 0.42
Unaided visual acuity – both eyes (LogMAR)	80	-0.18	1.30	0.25 ± 0.40
Unaided contrast sensitivity – right eye	80	0.00	2.25	1.79 ± 0.52
Unaided contrast sensitivity – left eye	80	0.30	2.25	1.80 ± 0.46
Unaided contrast sensitivity – both eyes	80	0.45	2.25	1.97 ± 0.36
Unaided depth perception score	80	0.00	600.00	450.00 ± 166.88

With optical correction, participants achieved near-normal visual acuity (Mean LogMAR ≈ -0.10), indicating effective correction of refractive errors. Contrast sensitivity improved (M ≈ 2.08–2.19) compared to unaided measures, and depth perception scores increased to 567.5 ± 86.8, showing enhanced binocular function with correction.

TABLE 5: CLINICAL AND VISUAL FUNCTION CHARACTERISTICS (AIDED VISION)

Variables	N	Minimum	Maximum	Mean ± SD

Variables	N	Minimum	Maximum	Mean ± SD
Aided visual acuity – right eye (LogMAR)	80	-0.18	0.00	-0.06 ± 0.05
Aided visual acuity – left eye (LogMAR)	80	-0.18	0.00	-0.07 ± 0.05
Aided visual acuity – both eyes (LogMAR)	80	-0.18	0.00	-0.10 ± 0.05
Aided contrast sensitivity – right eye	80	1.50	2.25	2.08 ± 0.20
Aided contrast sensitivity – left eye	80	1.50	2.25	2.10 ± 0.19
Aided contrast sensitivity – both eyes	80	1.95	3.25	2.19 ± 0.17
Aided depth perception score	80	200.00	600.00	567.50 ± 86.82

4.3 COMPARISON OF VISUAL FUNCTION MEASURES BETWEEN MYOPIC AND HYPERMYOPIC PARTICIPANTS

Continuous variables, including visual acuity (LogMAR), contrast sensitivity, and depth perception, were assessed for normality using the Shapiro-Wilk test. The results indicated that the data was not normally distributed ($p < 0.05$). Consequently, non-parametric tests, specifically the Mann-Whitney U test, were used for group comparisons between myopia and hypermyopia participants. A Mann-Whitney U test was conducted to compare visual function measures between participants with myopia and hypermyopia.

Unaided visual acuity was significantly poorer in myopic participants for the right eye ($U = 13.5$, $Z = -7.598$, $p < 0.001$), left eye ($U = 411.5$, $Z = -3.750$, $p < 0.001$), and both eyes ($U = 23.0$, $Z = -7.526$, $p < 0.001$). Unaided contrast sensitivity was significantly lower in myopia for all eyes ($p < 0.001$). Unaided depth perception was also significantly poorer in myopia ($U = 473.0$, $Z = -3.407$, $p = 0.001$).

After correction, aided visual acuity remained significantly lower in myopia across all eyes ($p \leq 0.001$). Aided contrast sensitivity was significantly lower in myopia for the right and left eyes ($p \leq 0.007$), but there was no significant difference when both eyes were combined ($p = 0.122$). Aided depth perception did not differ significantly between groups ($p = 0.303$).

Overall, myopic participants showed consistently poorer visual function compared to hypermyopic participants, especially in unaided conditions. More details are provided in the table.

TABLE 6: COMPARISON OF VISUAL FUNCTION MEASURES BETWEEN MYOPIA AND HYPERMYOPIA

Variable	Eye	Median (IQR) Myopia	Median (IQR) Hypermyopia	Mann-Whitney U	Z	p-value
Visual Acuity (LogMAR)	OD	0.60 (0.50–0.70)	0.20 (0.10–0.30)	13.5	-7.598	<0.001
	OS	0.50 (0.40–0.60)	0.30 (0.20–0.40)	411.5	-3.750	<0.001
	OU	0.60 (0.50–0.70)	0.20 (0.10–0.30)	23.0	-7.526	<0.001
Contrast Sensitivity	OD	0.30 (0.25–0.35)	0.50 (0.45–0.55)	285.0	-5.100	<0.001
	OS	0.30 (0.25–0.35)	0.50 (0.45–0.55)	367.5	-4.245	<0.001
	OU	0.28 (0.23–0.33)	0.54 (0.50–0.58)	257.5	-5.506	<0.001
Depth Perception	-	0.32 (0.28–0.36)	0.48 (0.44–0.52)	473.0	-3.407	0.001
Aided Visual Acuity (LogMAR)	OD	0.40 (0.30–0.50)	0.25 (0.20–0.30)	249.0	-5.590	<0.001
	OS	0.35 (0.25–0.45)	0.30 (0.20–0.35)	421.0	-3.876	<0.001
	OU	0.38 (0.30–0.48)	0.33 (0.25–0.40)	486.5	-3.218	0.001
Aided Contrast Sensitivity	OD	0.32 (0.28–0.36)	0.50 (0.45–0.55)	416.5	-4.012	<0.001
	OS	0.35 (0.30–0.40)	0.47 (0.42–0.52)	547.0	-2.684	0.007
	OU	0.37 (0.32–0.42)	0.43 (0.38–0.48)	676.0	-1.545	0.122
Aided Depth Perception	-	0.38 (0.33–0.43)	0.42 (0.37–0.46)	735.5	-1.031	0.303

4.4 COMPARISON OF AIDED VERSUS UNAIDED VISUAL FUNCTION IN PARTICIPANTS

Analysis was conducted to compare visual function in participants under unaided and aided conditions. Since the data was not normally distributed, the Wilcoxon signed-rank test was used to evaluate differences in binocular contrast sensitivity and depth perception scores between the two conditions. Results showed a significant improvement in both visual parameters when participants used their optical correction. For binocular contrast sensitivity, the test statistic was $W = 740.000$, $Z = 5.401$, $p < 0.001$, indicating a significant increase with aided vision. Similarly, depth perception scores improved significantly with optical correction ($W = 703.000$, $Z = 5.609$, $p < 0.001$). These findings suggest that the use of spectacles or contact lenses significantly enhances visual function in individuals with refractive errors.

Table 7: Wilcoxon Signed-Rank Test for Aided vs Unaided Visual Function

Variable	N	Test Statistic (W)	Standardized Z	Asymp. Sig. (2-tailed)
Contrast sensitivity (both eyes)	80	740.000	5.401	0.000
Depth perception score	80	703.000	5.609	0.000

4.5 CORRELATION BETWEEN DEGREE OF REFRACTIVE ERROR AND MEASURES OF VISUAL FUNCTION (VISUAL ACUITY, CONTRAST SENSITIVITY, AND DEPTH PERCEPTION)]

The Kruskal-Wallis test was used to evaluate differences in visual function across categories of refractive degree (mild, moderate, high) due to non-normal distribution of the data. For unaided measurements, there were significant differences across groups for visual acuity (both eyes: $H = 40.054$, $p < 0.001$), contrast sensitivity (both eyes: $H = 39.663$, $p < 0.001$), and depth perception ($H = 28.156$, $p < 0.001$). Similarly, aided visual acuity (both eyes: $H = 12.721$, $p = 0.002$) and aided depth perception ($H = 23.447$, $p < 0.001$) showed significant differences across refractive degree groups. However, aided contrast sensitivity did not differ significantly across groups (both eyes: $H = 3.710$, $p = 0.156$). These findings indicate that the degree of refractive error significantly influences most aspects of visual function, particularly visual acuity and depth perception, while aided contrast sensitivity appears less affected.

TABLE 8: CORRELATION BETWEEN DEGREE OF REFRACTIVE ERROR AND **MEASURES OF VISUAL FUNCTION**

Variable	**N**	**H (Kruskal-Wallis)**	**df**	**Asymp. Sig. (2-tailed)**
Unaided visual acuity – both eyes (LogMAR)	80	40.054	2	0.000
Unaided contrast sensitivity – both eyes	80	39.663	2	0.000
Unaided depth perception score	80	28.156	2	0.000
Aided visual acuity – both eyes (LogMAR)	80	12.721	2	0.002
Aided contrast sensitivity – both eyes	80	3.710	2	0.156
Aided depth perception score	80	23.447	2	0.000

CHAPTER FIVE

5.0 DISCUSSION

Vision is a critical sensory function that significantly influences daily activities and overall quality of life. While visual acuity is commonly used to assess refractive errors such as myopia and hyperopia, other important aspects of visual function like contrast sensitivity and depth perception are less commonly assessed thus limiting the knowledge of their impact and influence on myopia and hyperopia . This study aimed to assess the relationship between contrast sentivity and depth perception on refractive errors like myopia and hyperopia.

5.1 ASSESSMENT OF CONTRAST SENSITIVITY LEVELS IN INDIVIDUALS WITH MYOPIA AND HYPEROPIA

This study revealed that unaided contrast sensitivity (CS) was suboptimal in both myopic and hyperopic participants when compared with normative data for young adults, whose peak binocular contrast sensitivity typically reaches 2.1–2.3 log CS under photopic conditions (Pelli & Bex, 2013). The mean unaided binocular CS of 1.97 ± 0.36 log CS confirms that uncorrected refractive error through spherical defocus significantly degrades retinal image quality and impairs the discrimination of mid and high spatial frequency gratings that dominate daily vision tasks (Owsley, 2003).

Following optical correction, a statistically significant improvement ($p < 0.001$) was observed, with the mean aided contrast sensitivity rising to 2.19 ± 0.17 log CS. This gain illustrates the extent to which optical blur accounts for contrast sensitivity loss in refractive errors. Similar restoration after refraction has been documented by Kebede *et al.* (2023) and Thatte *et al.* (2023), both reporting marked contrast sensitivity recovery once spherical error was corrected. Nonetheless, the persistence of slightly lower mean contrast sensitivity compared with

published emmetropic norms suggests that subtle neural or higher-order optical aberrations may remain even after standard correction (Wang *et al.,* 2024).

Residual deficits were most pronounced in high-myopia subgroups, in which structural retinal changes including axial elongation, reduced cone density, and choroidal thinning have been shown to compromise contrast sensitivity independently of refractive correction (Wang *et al.,* 2024; Shiqlabu *et al.,* 2024).

5.2 TO EVALUATE DEPTH PERCEPTION (STEREOPSIS) IN INDIVIDUALS WITH MYOPIA AND HYPEROPIA

In the uncorrected state, mean unaided stereopsis was poor, recorded at 450.00 ± 166.88 arcseconds. This level of stereopsis is considered subnormal, as fine stereopsis is typically defined as 60 arcseconds or better. The large variability observed reflects the combined effects of uncorrected blur and potential suppression in eyes with higher refractive asymmetry. These findings agree with Tilahun *et al.* (2021), who reported degraded stereopsis in uncorrected ametropia and emphasised the dependence of stereoacuity on retinal image clarity.

Optical correction significantly improved stereo thresholds ($p < 0.001$), yielding a mean of ≈ 568 ± 87 arc sec, a clinically meaningful gain even though some participants did not reach normal limits.. Comparable post-correction gains have been described by Elamurugan *et al.* (2022) and Qayyum *et al.* (2022), who found that precise refractive correction restores the disparity processing necessary for depth perception.

Persistent variability among corrected participants likely reflects long-term neural adaptation to uncorrected blur or subtle aniseikonia in high refractive errors. Prolonged blur can alter binocular integration pathways, and in high myopia axial elongation may introduce slight

magnification differences between eyes that reduce stereo precision (Ziarat *et al.,* 2024). Overall, the present results affirm that depth perception deficits in refractive errors are primarily optical in origin and largely reversible through appropriate correction, provided that binocular pathways remain anatomically intact.

5.3 COMPARISON OF THE DIFFERENCES IN CONTRAST SENSITIVITY BETWEEN MYOPES AND HYPEROPES

Between-group comparisons demonstrated that myopic participants exhibited significantly lower contrast sensitivity than hyperopes in both unaided and aided conditions ($p \leq 0.007$ for right and left eyes). Unaided mean CS was 1.78 log CS for myopes and 2.15 log CS for hyperopes, consistent with the optical implications of their respective refractive signs. Myopic defocus produces a larger retinal blur circle for distant targets, disproportionately attenuating higher spatial frequencies, whereas mild hyperopes may compensate for near to intermediate distances through accommodation, particularly in younger people.

This pattern corroborates previous findings that myopia exerts a stronger negative influence on contrast sensitivity than hyperopia (Kebede *et al.,* 2023; Thatte *et al.,* 2023). Even after correction, myopes in the present study retained slightly reduced CS (2.16 vs 2.23 log CS), suggesting persistent neural or structural factors, echoing Wang *et al.* (2024) and Xu *et al.* (2022), who linked post correction contrast sensitivity deficits in high myopia to retinal microstructural alterations.

Conflicting literature occasionally reports the reverse pattern hyperopes performing worse than myopes (Bilal *et al.,* 2020) but such discrepancies generally arise from differences in age distribution, lack of cycloplegia, or inclusion of latent hyperopia that increases

accommodative strain. The relatively young, low to moderate hyperopic sample here likely explains the superior hyperopic performance, as accommodation mitigated blur during testing.

5.4 COMPARISON OF THE DIFFERENCES IN DEPTH PERCEPTION BETWEEN MYOPES AND HYPEROPES

Consistent with the contrast sensitivity findings, myopes demonstrated poorer unaided stereopsis (mean ≈ 385 arc sec) than hyperopes (≈ 512 arc sec), a statistically significant difference ($p = 0.001$). This relationship between image clarity and binocular disparity sensitivity has been extensively described: degraded monocular input reduces the precision of inter-ocular matching necessary for fine depth judgments (Pelli & Bex, 2013; Owsley, 2003).

After correction, the difference in stereopsis between myopes and hyperopes became statistically non-significant ($p = 0.303$). The convergence of aided stereo scores 558.9 arc sec for myopes versus 575.6 arc sec for hyperopes indicates that the neural mechanisms for depth perception remain functional once optical clarity is restored. Comparable normalisation has been reported by Habiba and Hussein (2022) and Qayyum *et al.* (2022), reinforcing that refractive blur, rather than cortical deficiency, underlies most stereo deficits in ametropia. Nevertheless, minor residual differences may persist in high myopia cases due to aniseikonia, subtle suppression, or long-term adaptation to asymmetrical retinal images (Tilahun *et al.,* 2021; Ziarat *et al.,* 2024). Such effects underscore the complex interaction between optical quality and binocular integration.

5.5 TO DETERMINE THE CORRELATION LEVEL BETWEEN THE DEGREE OF REFRACTIVE ERROR WITH CONTRAST SENSITIVITY AND DEPTH PERCEPTION

A strong, graded relationship emerged between the magnitude of refractive error and unaided visual performance. Participants with higher refractive errors demonstrated worse unaided acuity, contrast sensitivity, and stereopsis (all $p < 0.001$), consistent with optical theory and empirical data from Shiqlabu *et al.* (2024) and Wang *et al.* (2024). The effect of refractive degree persisted post-correction for visual acuity ($p = 0.002$) and stereopsis ($p < 0.001$) but not for aided contrast sensitivity ($p = 0.156$), indicating that standard optical correction effectively equalises contrast sensitivity across degrees of ametropia, whereas residual binocular disparities continue to limit stereopsis in high refractive error cases.

The incomplete recovery of stereopsis in high refractive errors likely reflects neural adaptation,reduced cortical disparity sensitivity or mild amblyopia arising from prolonged unequal image quality during visual development. Similar dose-dependent stereopsis reductions have been observed by Elamurugan *et al.* (2022) and Tilahun *et al.* (2021). This dissociation normalised contrast sensitivity but persistently variable stereosis indicates that stereopsis requires not only sharp monocular images but also symmetrical inter-ocular representation and prior binocular experience.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 CONCLUSION

This study comparatively evaluated contrast sensitivity (CS) and depth perception (stereopsis) among individuals with myopia and hyperopia, providing valuable insights into how refractive status influences visual performance beyond standard high-contrast visual acuity. The findings confirmed that while both groups may exhibit normal visual acuity when optimally corrected, significant functional differences exist in their ability to discern contrast and perceive depth, underscoring the limitations of visual acuity as a sole indicator of visual quality.

Clinically, these results from this study emphasize that routine eye examinations should include contrast sensitivity and stereopsis assessment, especially in refractive patients who report visual discomfort or reduced performance in low contrast or three-dimensional environments despite good Snellen acuity. Understanding the differential impact of refractive errors on visual function enhances personalized vision care, lens design, and patient counseling. Additionally, the results have implications for occupational vision standards, driving fitness evaluations, sports vision training, and rehabilitation strategies in patients with refractive or binocular vision anomalies.

In summary, this research establishes that both contrast sensitivity and depth perception are significantly influenced by refractive status, with myopes generally demonstrating poorer performance compared to hyperopes. Comprehensive evaluation of these parameters provides

a more accurate representation of functional vision, reinforcing the clinical importance of going beyond conventional visual acuity testing in optometric practice.

6.1 RECOMMENDATIONS

1. Incorporation contrast sensitivity and stereopsis testing into routine optometric evaluations, particularly for individuals with refractive errors to detect subclinical visual performance deficits.

2. Eye care practitioners should interpret best corrected visual acuity in conjunction with functional visual parameters such as contrast sensitivity and stereoacuity to better assess visual quality and patient-reported outcomes.

3. Patient education should emphasize the importance of regular eye examinations and early correction of refractive errors to prevent functional visual deficits and maintain binocular balance.

4. Future studies should employ objective psychophysical and computerized testing methods, such as the Quick Contrast Sensitivity Function (qCSF) and digital stereopsis assessments, to enhance measurement precision and clinical applicability.

5. Occupational and sports vision programs should include assessments of contrast sensitivity and stereopsis to ensure safety and performance efficiency in visually demanding environments.

6. Further longitudinal research is recommended to evaluate the long term effects of refractive correction, optical interventions, and visual training on contrast sensitivity and depth perception across different age groups.

7. Integration of adaptive optics and neural based visual training could be explored as potential interventions to improve functional vision in individuals with high myopia or residual hyperopia.

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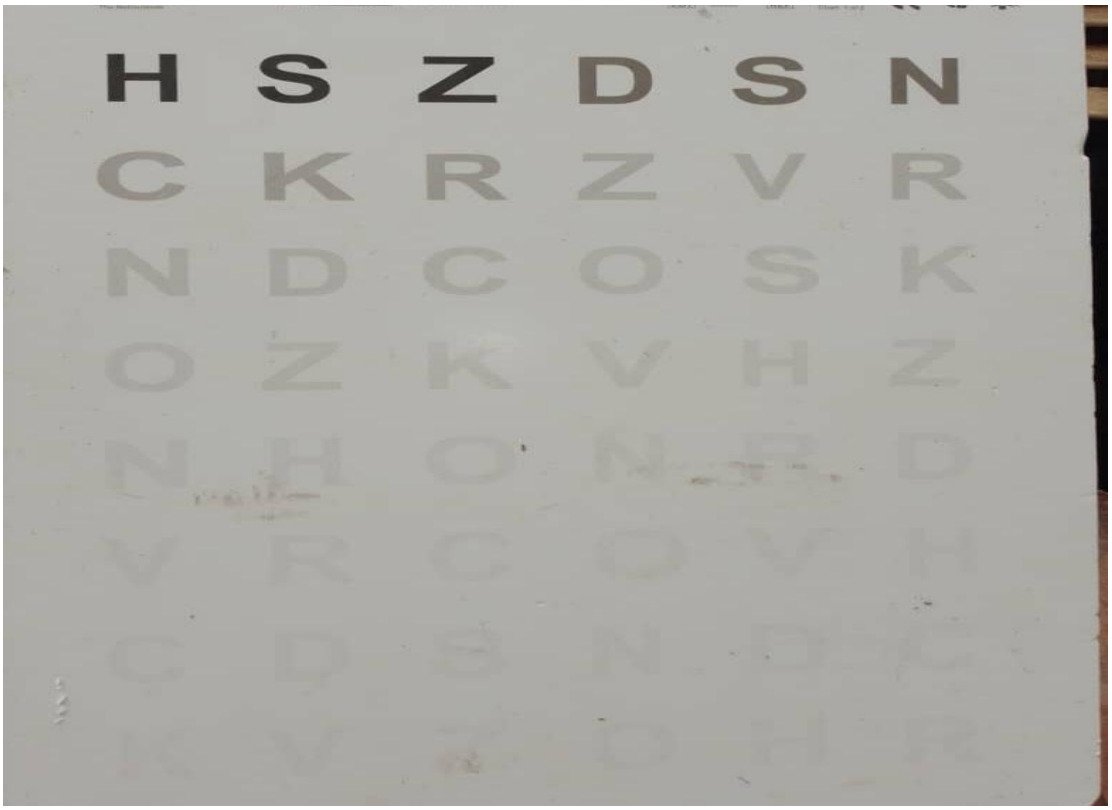
APPENDIX I

APPENDIX II


LANG STEREOTEST II®
Distance:30–40 cm
MOON
Disparity: 200"
STAR (always visible)
Disparity: 200"
ELEPHANT
Disparity: 600"
TRUCK
Disparity: 400"
LANG-STEREOTEST AG
CH-8700 Küsnacht
Switzerland
www.lang-stereotest.com
LOT 015 2014-01-30
LANG-STEREOTEST®


H S Z D S N
C K R Z V R
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APPENDIX II

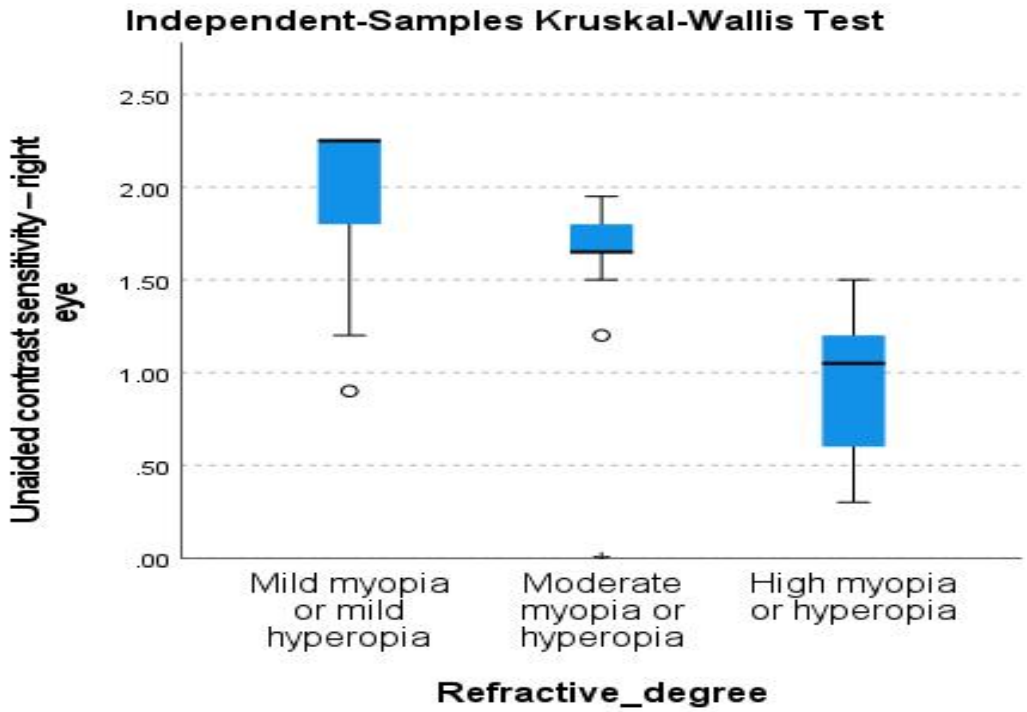

FIGURE 3: UNAIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (RIGHT EYE)

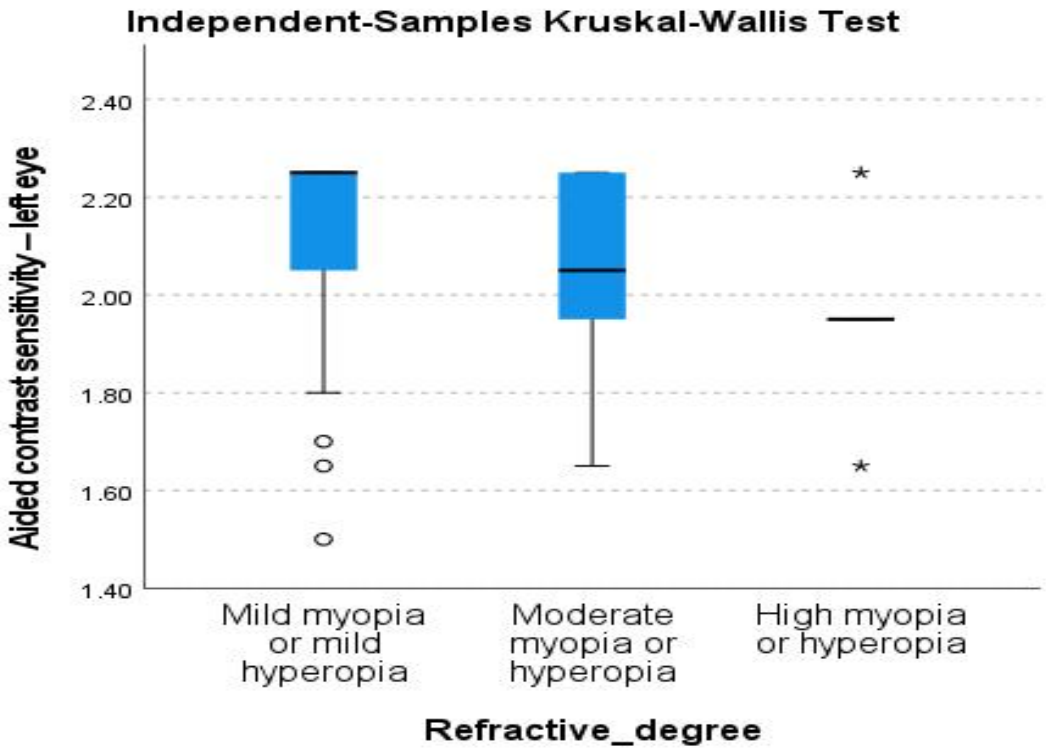

FIGURE 4: UNAIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (LEFT EYE)

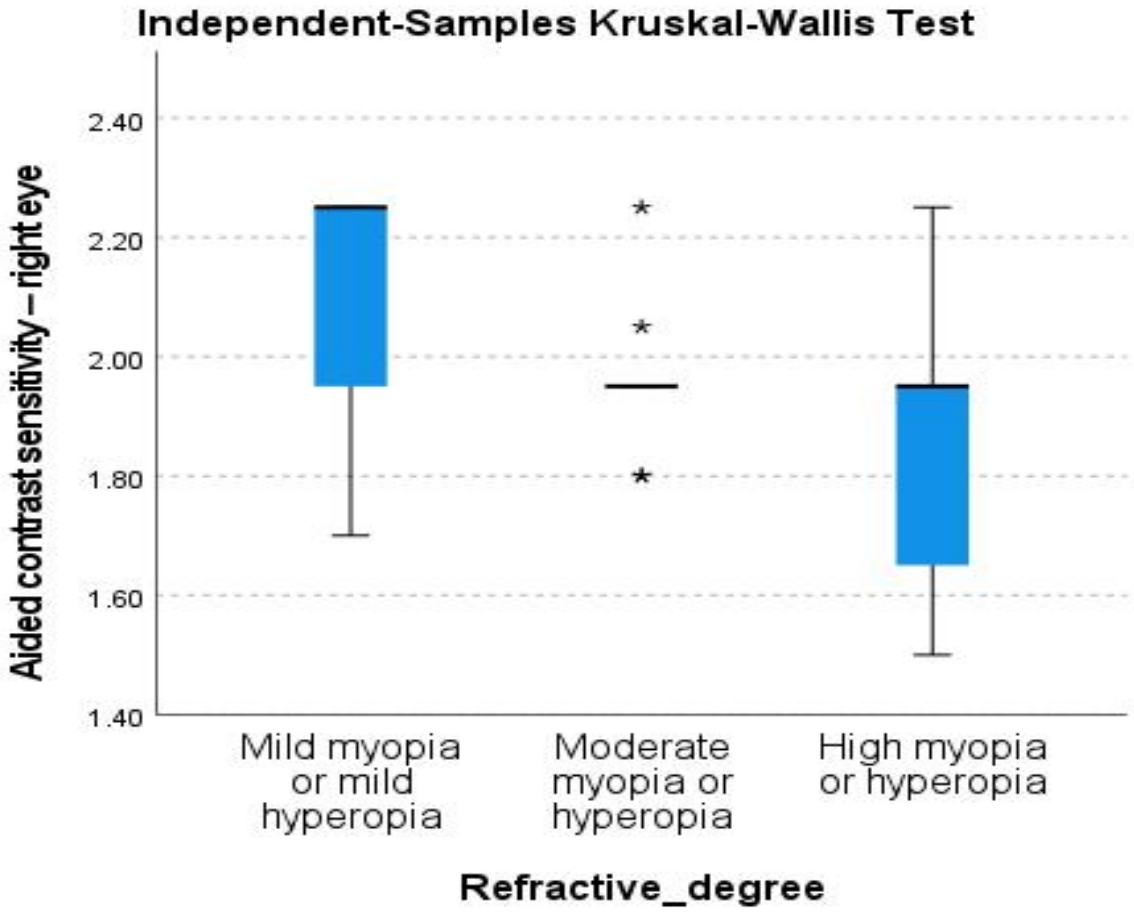

FIGURE 5: UNAIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (BOTH EYES)

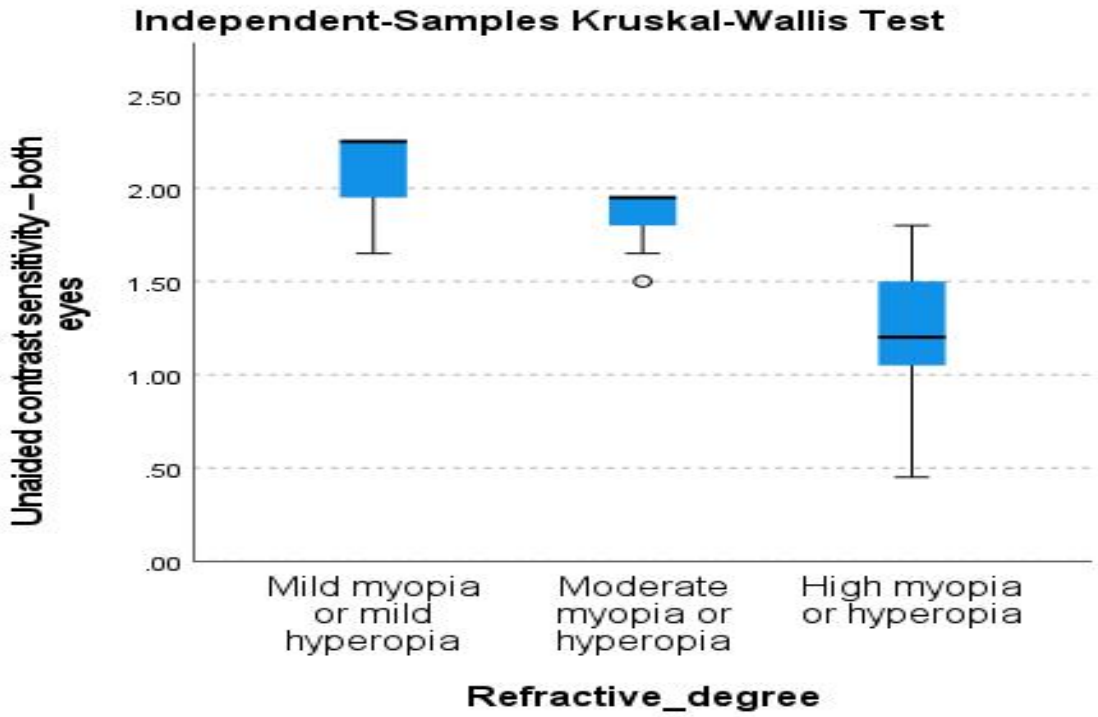

FIGURE 6: AIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (RIGHT EYE)

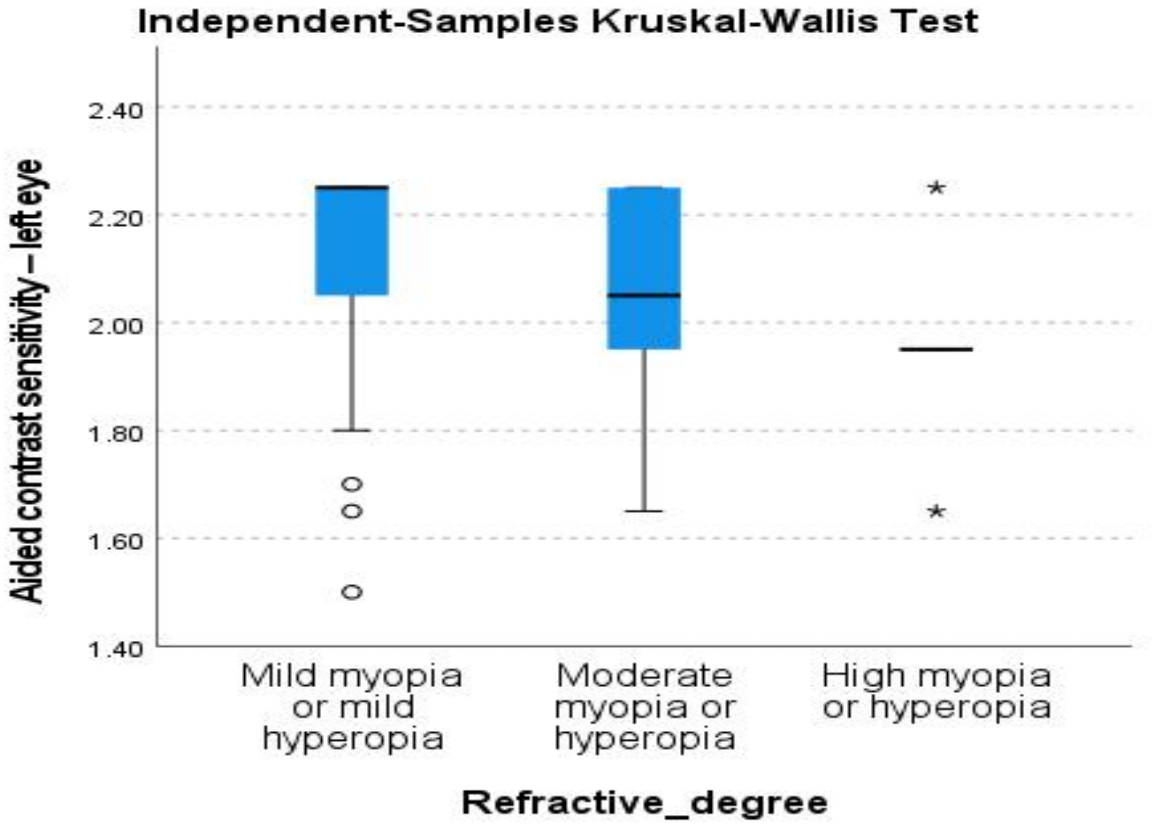

FIGURE 7: AIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (LEFT EYE)

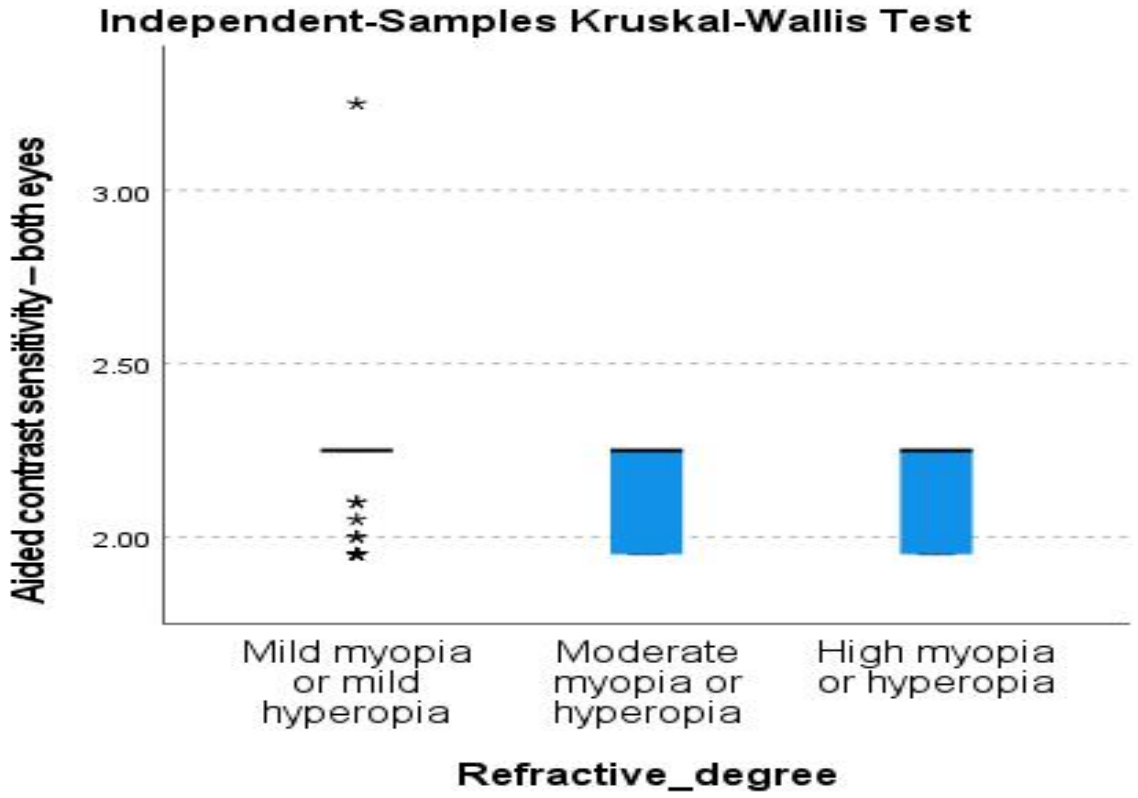

FIGURE 9: AIDED CONTRAST SENSITIVITY VS. REFRACTIVE DEGREE (BOTH EYES)

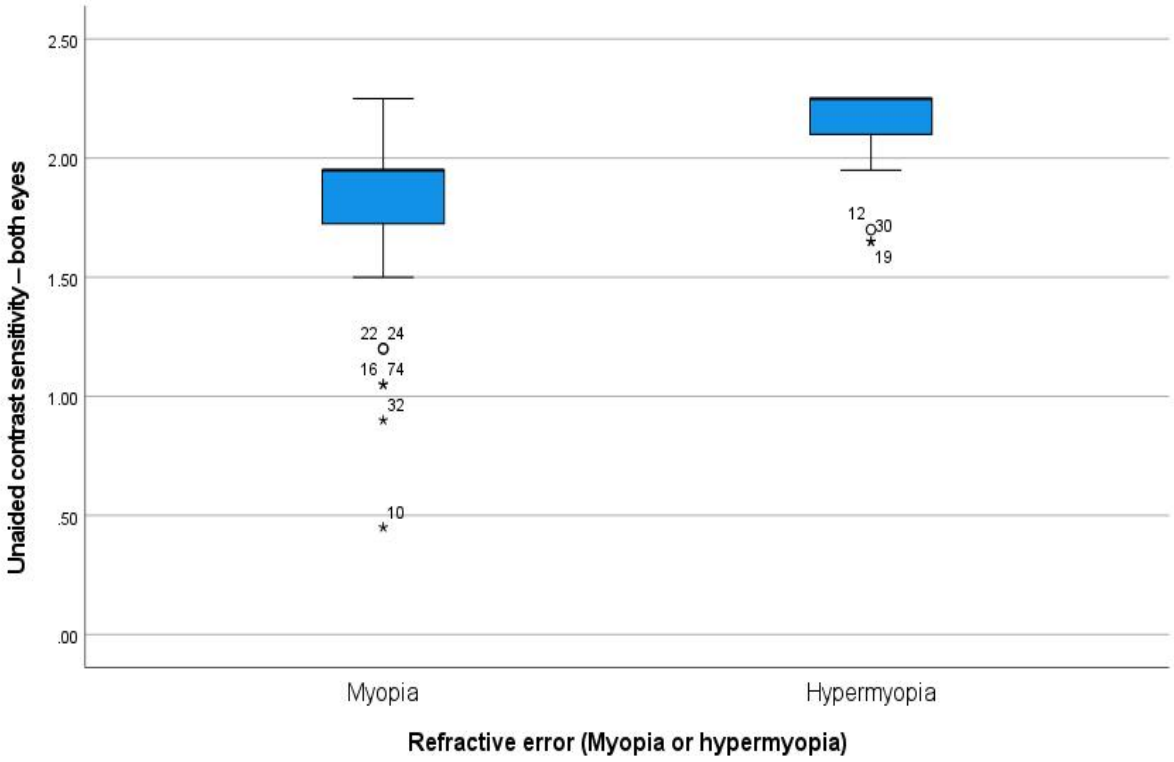

FIGURE 10: BOXPLOT SHOWING THE DISTRIBUTION OF UNAIDED CONTRAST SENSITIVITY (BOTH EYES) ACROSS REFRACTIVE ERROR TYPES

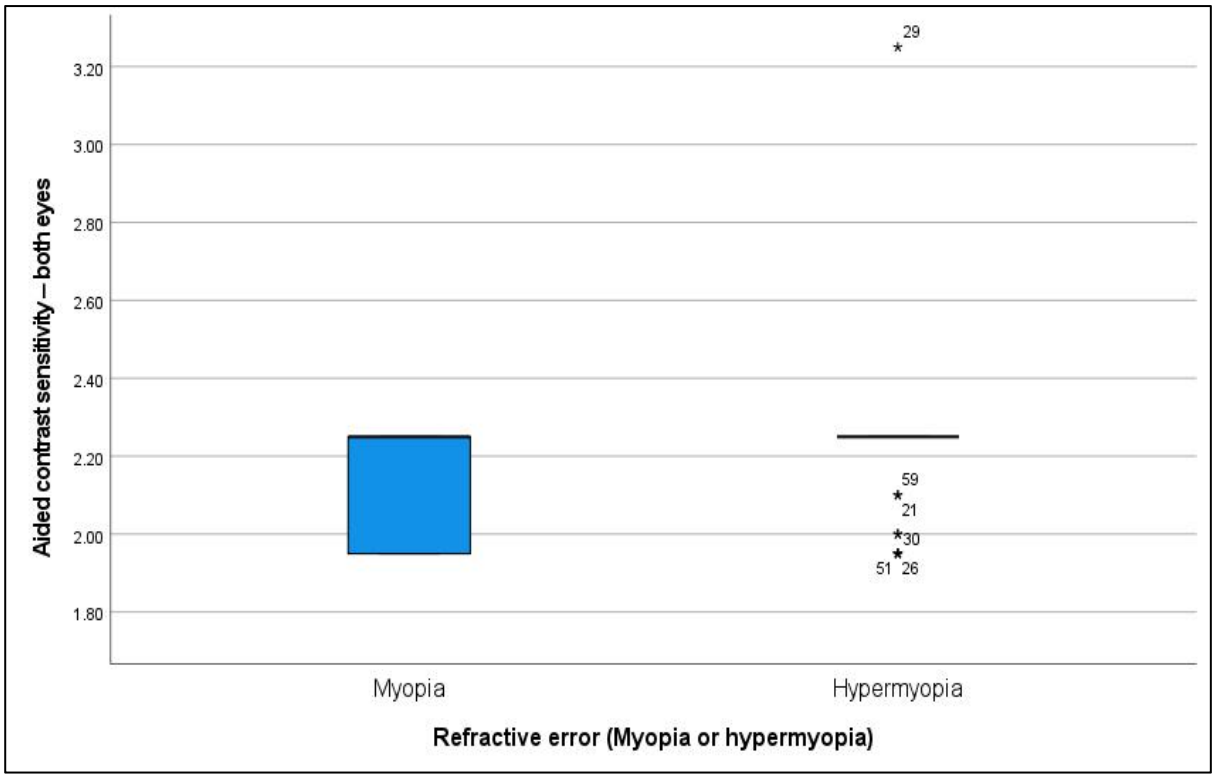

Table 11 : Boxplot showing the distribution of aided contrast sensitivity (both eyes) across refractive error types

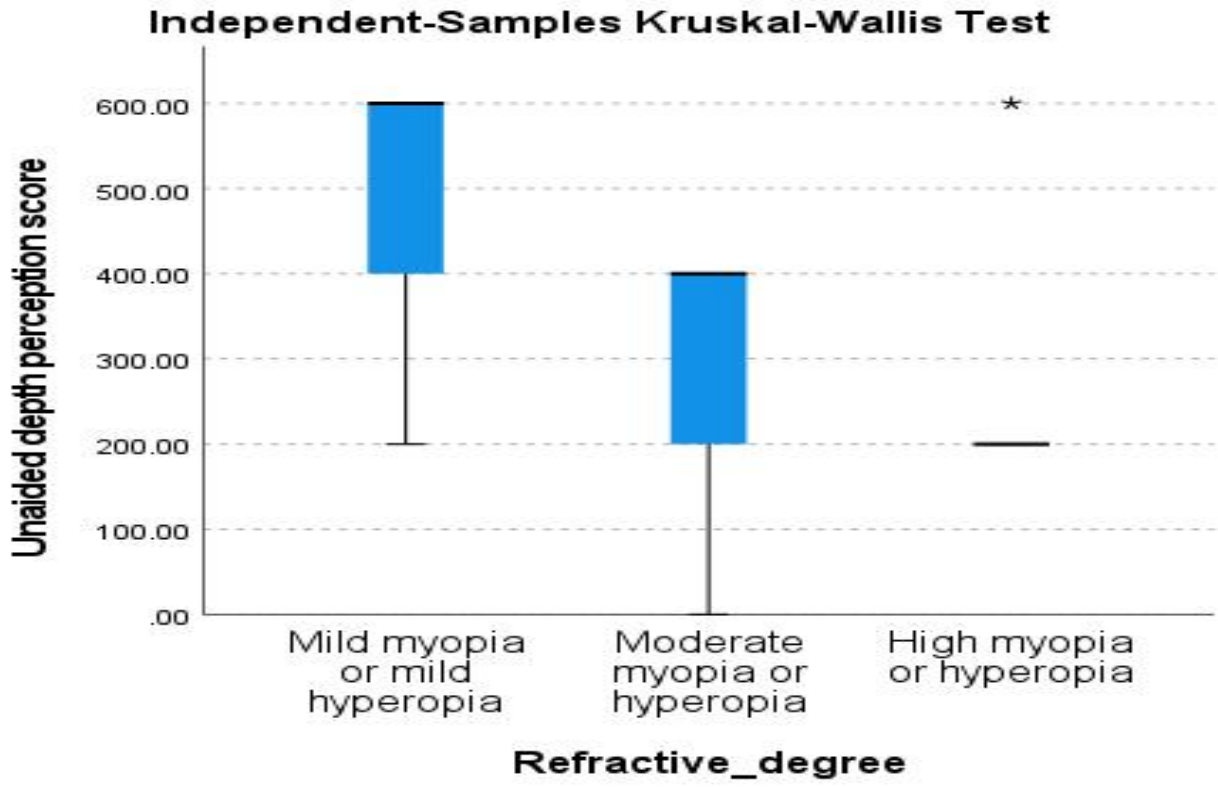

Figure 6: Unaided Depth perception score vs Refractive degree

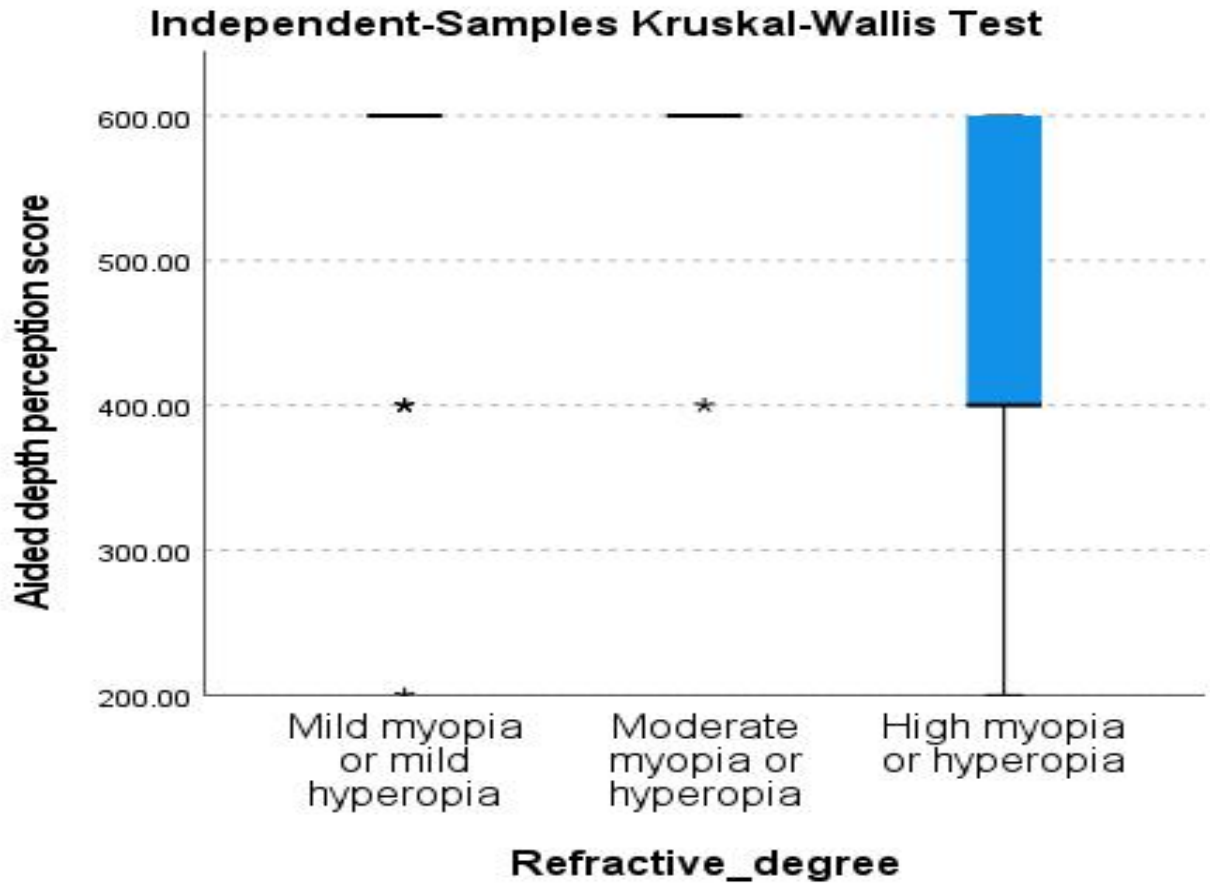

FIGURE 9: AIDED DEPTH PERCEPTION VS. REFRACTIVE DEGREE (BOTH EYES)